KTA-TATOR, INC.

Adaption of Japanese Prefabrication Priming Procedure to U.S. Shipbuilding Methodology

TASK 3-79-1

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FORWARD

The Maritime Administration under its National Shipbuilding Research Program sponsored this laboratory study. Avondale Shipyards, Inc., administered the program for the Maritime Administration with Mr. John Peart, formerly of the Avondale Shipyards, acting as the Technical Administrator. All of the experimental work described in this report took place at the KTA-Tator, Inc. laboratory in Pittsburgh, Pennsylvania, with ocean-front exposure accomplished at the Ocean City Research Corporation laboratory in Ocean City, New Jersey. The project was performed under the direction of Mr. Kenneth A. Trimber and Mr. William D. Corbett of KTA.

The research study investigated the U.S. and Japanese shipbuilding prefabrication priming procedures. In both countries, a thin film (0.7 roils) inorganic zinc pre-construction primer is applied to the steel prior to fabrication. Current U.S. shipbuilding practices require that the pre-construction primer be removed by blast cleaning after fabrication, followed by a new zinc prime coat, and the remainder of the coating system. In Japan, the original pre-construction primer is minimally cleaned with power tools after fabrication, but not removed. Instead, it becomes a component of the final protective coating. If the Japanese methodology is proven to provide comparable, or even adequate~ service the result would be a substantial cost savings during shipbuilding. As the overall shipbuilding-related costs in U.S. shipyards, the subject study was initiated to investigate comparative performance.

EXECUTIVE SUMMARY

The U.S. and Japanese Marine shipbuilding coating practices currently involve the application of a reconstruction primer to blast cleaned steel prior to fabrication. After fabrication, the Japanese incorporate this primer into the protective coating system after minimal cleaning (Steel Structures Painting Council SSPC-SP3), "Power Tool Cleaning"). In contrast, the U.S, removes this primer by blast cleaning in accordance with Steel Structures Painting Council SSPC-10, "Near-White Blast Cleaning" followed by the application of a new inorganic zinc primer and the remainder of the coating system. The result is an escalation in the U.S. costs of coating application as compared with the Japanese methodology. If the Japanese approach provides adequate performance, a significant cost savings would result. In order to investigate this, Avondale Shipyards acting on behalf of the Maritime Administration under the National Shipbuilding Research Program authorized KTA-Tator, Inc. to undertake a laboratory study to investigate the performance of six selected Marine coatings applied according to the U.S. and Japanese methodologies. Products from two Japanese suppliers and two U.S. suppliers were used.

In general the results of four accelerated weathering tests (six-month 150° salt water immersion, cycled pressurized immersion at 80 psi head pressure, alternating UV/heat/immersion cycling, and salt fog exposure) show the U.S. methodology provides better performance in some cases, while the Japanese approach provides better performance in other. Overall, it appears that the Japanese methodology should be strongly considered for U.S. use.

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INTRODUCTION

The National Shipbuilding Research Program discussed in this paper was designed to compare to U.S. and Japanese methodologies when used with six different coating systems: coal tar epoxy, polyamide epoxy, inorganic zinc, chlorinated rubber, vinyl, and bleached tar.

Products from two Japanese suppliers and two U.S. suppliers were used. The Japanese materials were applied following the Japanese methodology only (incorporating the pre-construction primer into the final system) while the U.S. materials were applied following both methodologies (incorporating the pre-construction primer into the final system, as well as total removal and replacement of the primer.

The objective of the study was to compare methodologies through the use of U.S. products applied according to both the U.S. and Japanese approaches. **Also,** although not originally intended as one of the research objectives, a great deal of information has evolved from this study with regard to the comparative performance of the various generic types of coatings tested (both U.S. and Japanese products), as well as notable differences in the performance between products of the same generic type.

KTA-Tator, Inc., was directed to investigate the research objective through specific accelerated weathering laboratory tests in addition to an 18-month ocean-front field exposure. The Ocean City Research Corporation test site in Ocean City, New Jersey was selected for the field exposure. The laboratory accelerated weathering was performed at KTA and included:

- Six-month 150″F salt water immersion

- Cycled pressurized immersion at 80 psi head pressure (three-seventeen day cycles)

- Two month alternating UV/heat/immersion cycling (KTA Envirotest)

- Salt fog exposure (2000 hours).

The following report summarized the results of the study.

CONCLUSIONS

The test results were found to be very product (brand) dependent. That is, all manufacturers' epoxies, for example, did not perform similarly. Additionally, the performance varied according to generic type. Therefore, the performance of the systems must be viewed individually, rather than generalizing the results of all systems/manufacturers combined.

Summarized results are shown below for the two U.S. manufactured coating lines tested (identified as US-A and US-B) for which both the U.S. and Japanese methodologies were followed:

Coal Tar Epoxy	US-A	US Methodology slightly better than Japanese.
	US-B	US Methodology equivalent to Japanese.
Polyamide Epoxy	US-A	US Methodology slightly worse than Japanese.
	US-B	US Methodology better than Japanese.
Inorganic Zinc	US-A	US Methodology equivalent to Japanese.
	US-B	US Methodology significantly better than Japanese.
Chlorinated Rubber	US-A	US Methodology slightly better than Japanese.
	US-B	US Methodology significantly worse than Japanese.
Vinyl	US-A	US Methodology slightly worse than Japanese
Bleached Tar	US-B	US Methodology better than Japanese.

From the test results, it is apparent that the costly U.S. methodology is not clearly superior to the Japanese, as better, equivalent, and worse performance has resulted.

The system showing poorer performance under the U.S. methodology may be a function of the degree of cure of the inorganic zinc primer. Under the Japanese methodology, the pre-construction primer is thin and well-cured at the time of finish coating. In contrast, the U.S. system employs fresh zinc primer which may not possess the high degree of cure at the time of topcoating that is afforded by the Japanese approach. Although the manufacturers' recoat times were observed, previous KTA studies have shown that the published cure times prior to topcoating may be somewhat optimistic. And in this program, the minimum cure times were typically followed.

Despite the reasons for the differences in performance, the test program does not indicate that a significant increase in longevity will result by removing and replacing the zinc primer prior to application of the finish system.

EXPERIMENTAL APPROACH

GENERAL TEST PLAN

The general test plan involved the evaluation of six different finish coating systems either applied directly to weathered pre-construction inorganic zinc primer, or to fresh inorganic zinc primer which was applied to the steel after the blast cleaning removal of the pre-construction coating. Products from two Japanese manufacturers and two U.S. manufacturers were used. This resulted in twelve unique coating system/surface preparation variable combinations.

Prepared test panels were exposed to four accelerated weathering test environments: (1) Six-month 150°F salt water immersion, (2) Three-seventeen day cycles consisting of pressurized immersion (80 psi head pressure for 14 days) and repressurized exposure (3 days at atmospheric), (3) Two months alternating UV/heat/immersion cycling (KTA Envirotest), and (4) Salt fog (2,000 hours). In addition to the accelerated tests, an 18-month ocean-front field exposure was included.

COATINGS SELECTED FOR TESTING

Table 1 presents the coating systems selected for testing under both the Japanese and U.S. methodologies. Products from two U.S. manufacturers and two Japanese manufacturers were utilized. Complete systems supplied by the manufacturers were used; products from different suppliers were not intermixed. The coatings were selected as being typical high performance ship coatings commonly used in the United States, Japan or both. The systems are coded as Japanese Manufacturer A and B, and U.S. Manufacturer A and B with generic identifications provided. However, the specific products used and thicknesses per coat are shown in Appendix 1.

TEST PANEL PREPARATION

Test coupons for the programs were fabricated to simulate the procedures used in the shipbuilding industry. Mill scale bearing carbon steel test plates

1/4″ x 14″ x 34″ in size were blast cleaned using #24 aluminum oxide grit to a degree of cleaning in accordance with Steel Structures Painting Council SSPC-SP10, “Near-White Blast Cleaning”. A 2.0 to 2.5 mil surface profile was obtained.

Weldable pre-construction shop primers from each of the four coating suppliers were applied by automatic spray to both sides of the test plates at a film thickness from 0.5 to 0.7 roil. Approximately eleven (11) plates were coated with each primer.

Conventional (air) spray was used, consisting of a DeVilbiss Type AGB automatic spray gun fitted with a pressurized pot and individual pot and atomization pressure controls. An EX tip and needle assembly and a No. 704 air cap were used or the application of the pre-construction primers. The spray gun and pressure pot are mounted on an electric/hydraulic arm which controls both the traverse rate of the spray gun and the gallons per minute (gpm) flow rate of the materials. The automatic sprayer provides consistent control of the film thickness required for this type of application.

The primers were allowed to cure for approximately one to two weeks, then the large 14″ x 34″ test plates were cut into 6“ x 10″ test coupons using an acetylene torch. The panels were flame cut rather than sawed in order to simulate shipbuilding cutting (burning) procedures, so that the effect of heat on the pre-construction primers might be evaluated. After cutting, a weld bead approximately 6“ in length was deposited onto the front side of each test panel to simulate shipbuilding welding practices, and to create a heat effected zone on the backside.

The pre-construction primers were subsequently weathered by placing the coupons outdoors (Pittsburgh, Pennsylvania) for a four to six week period during April, May and June 1985. The natural weathering was accelerated by a daily tap water wash and a weekly 0.5% sea salt water wash.

After the outdoor exposure, the zinc primers exhibited white zinc salts and the weld bead and edges of the coupons contained medium to tightly adherent red

rust. The appearance was felt to be representative of pre-construction zinc primers after fabrication.

The panels were thoroughly rinsed with fresh tap water prior to further surface preparation. The four sets of panels representing the Japanese methodology (two Japanese and two U.S. suppliers) were power tool cleaned using a No. 16 mesh disc-type sanding wheel. The cleaning removed the zinc oxides and loose rust, but allowed approximately 90% of the pre-construction primer to remain in place. The weld bead and edges were prepared using a rotary cup wheel, and cleaned to "Bright Metal". After preparation, those panels designated for immersion tests were "stripe-coated" along the weld bead and edges using a brush-applied organic zinc-rich supplied by the respective coating manufacturers. Figures 1 through 5 depicts test panel condition after weathering and after power tool cleaning zinc-rich striping of welds.

The remaining sets of coupons from the two U.S. suppliers (representing the U.S. methodology) were blast cleaned in accordance with Steel Structures Painting Council SSPC-SP1O, "Near-White Blast Cleaning". This resulted in complete removal of the pre-construction primers. An inorganic zinc-rich coating was reapplied.

The finish coats were applied to the six sets of panels at the same time. After sufficient cure of the topcoat materials, the panels were subjected to the accelerated weathering tests and field exposures.

TABLE 1
COATING SYSTEMS TESTED

	JAPANESE METHODOLOGY[1]						U.S. METHODOLOGY[2]					
Mfg.	Coal Tar Epoxy	Poly. Epoxy	Inorg. zinc	Chlor. Rub.	Vinyl	Bleach Tar	Coal Tar Epoxy	Poly. Epoxy	Inorg. Zinc	Chlor. Rub.	Vinyl	Bleach Tar
U.S. (Mfg. A)	x	x	x	x	x		x	x	x	x	x	
U.S. (Mfg. B)	x	x	x	x		x	x	x	x	x		x
Jap. (Mfg. A)	x	x	x	x	x	x						
Jap. (Mfg. B)	x	x	x	x	x	x						

1 - Spot. clean weathered preconstruction primer with power tools and apply finish system.

2 - Remove weathered preconstruction primer by blast cleaning (SSPC-SP10 "Near-White'); apply inorganic zinc prime coat and remainder of finish system.

FIGURE 1 - Test Panels after exposure (front)

FIGURE 2 - Test Panels after Exposure (back)

Figures 1 through 5 depicts test panel condition after exposure to weather, after power tool cleaning and after stripe coating.

FIGURE 3 - Test Panels power tool cleaned (front)

FIGURE 4 - Test Panels power tool cleaned (back)

Figures 1 through 5 depicts test penel condition after exposure to weather, after power tool cleaning and after stripe coating.

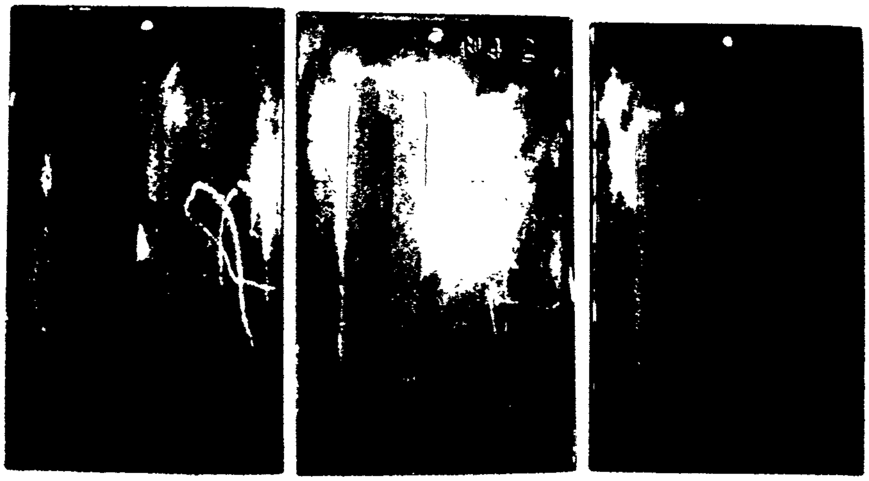


FIGURE 5 - Weld areas touched up with expoxy zinc-rich

Figures 1 through 5 depicts test panel condition after exposure to weather, after power tool cleaning and after stripe coating.

TEST EXPOSURES

Duplicate test panels of each coating system variable combination were exposed to the weathering tests described below.

Salt Fog

Salt fog testing was performed in accordance with ASTM B 117 "Standard Method of Salt Spray (Fog) Testing". A total of 2,000 hours of exposure were used.

Salt Water Immersion at 150"F

The test panels were totally immersed in a 3% solution of synthetic sea salt **water heated to 150°F ± 5°F.** In addition, an aerating tube was included in the chamber. The test design was six months.

80 psi Head Pressure Cycling

A pressurized/depressurized immersion test was comprised of three cycles conforming to the following schedule:

- 14 days of 3% synthetic sea salt water immersion at 80 psi
- 3 days drying at atmospheric pressure.

The test panels were graded after the first, second and third cycles. The results after the third and final cycle are reported.

KTA ENVIROTEST

The Envirotest automatically cycles panels in immersion (3% simulated sea salt water) and drying under heat/ultraviolet lamps at a temperature of 130"F. The cycle consists of approximately one hour immersion followed by one hour of

drying on a 24 hour per day-seven day per week basis. The test was designed for a total of two months exposure. Because of the limited capacity of the test apparatus, the panels were exposed in three sets.

Field Exposure

Test panels were exposed eighteen months at ocean City Research Corporation's Sea' Isle test site. They were exposed facing south at 45° and were sprayed daily with sea water.

INSPECTION/EVALUATION PROCEDURES

Each of the grading areas (plane surfaces front and back, weld, heat affected zone, edges and scribe) were graded individually for corrosion (ASTM D 714 "Evaluating Degree of Blistering of Paints"), cracking, delamination, or other defects. The raw data for each of the grading areas was then converted into a O-4 rating scale to provide a single performance number, allowing for system-to-system comparisons to be made. The specific results of each system (raw data) are shown on the attached tables:

Table 2	2,000 Hours Salt Fog - Test Results - Blistering/Corrosion
Table 3	Sea Water Immersion at 150"F - Test Results - Blistering/Corrosion
Table 4	80 psi Head Pressurize Cycling - Test Results - Blistering/Corrosion
Table 5	KTA Envirotest - Test Results - Blistering/Corrosion.

The basis for the O-4 rating scale is shown below:

Front and Back Plane Surfaces

ASTM D 714/Blister/Size Frequency

Rating	3.5	3.0	2.5	2.0	1.0
	8F	8M	8MD	8D	
	6F	6M	6MD	6D	
Blisters	4F	4M	4MD	4D	
	2F	2M	2MD	2D	

ASTM D 610 Rust Grades

Rust Grade 9	Rating - 3.5
Rust Grade 8	Rating - 3.0
Rust Grade 6-7	Rating - 2.5

Weld Area and Heat Effected Zone

Ratings follow the blister tables shown above for front and back plane surfaces. In addition, a rating of 1.0 is subtracted from each when corrosion is present.

Edges

Rating 4.0 - No corrosion
Rating 3.0 - Light rusting
Rating 2.5 - Light rusting with slight blistering
Rating 2.0 - Heavy rusting
Rating 1.0 - Heavy rusting plus a few blisters
Rating 0.5 - Heavy rust plus many blisters.

Scribe

Rating 4.0 - No defects

Rating 3.0 - Light rust or few blisters

Rating 2.5 - Light rust with blisters

Rating 2.0 - Heavy rust

Rating 1.5 -,Heavy rust with blisters (4F, 6F, 8F)

Rating 1.0 - Heavy rust with blisters (2F)

Rating 0.5 - Heavy rust plus many blisters

Weight Average

It is acknowledged that scribes, welds and edges will be more prone to failure than plane areas. In order to account for this difference, the ratings for the front and back sides of the panels were given a weight of 2X while the ratings for the irregularities were given a weight of 1X when the average test panel total rating numbers were compiled.

TEST RESULTS

The cumulative coating system ratings are presented in two different formats on the attached tables. The first shows a comparison of the performance of the coating systems in each accelerated test environment:

Table 6 - System Rating - KTA Envirotest

Table 7 - System Rating - 80 psi Pressurized/Depressurized Cycle

Table 8 - System Rating - Salt Fog

Table 9 - System Rating - Sea Water Immersion at 150°F

Table 10 - Average System Rating - Combined Test Exposures.

The laboratory test data is then reorganized per coating system. This allows for a comparison of the performance of the same generic type in each of the accelerated test environments. The tables are:

Table 11 - Exposure Ratings - Coal Tar Epoxy

Table 12 - Exposure Ratings - Polyamide Epoxy

Table 13 - Exposure Ratings - Inorganic Zinc

Table 14 - Exposure Ratings - Chlorinated Rubber

Table 15 - Exposure Ratings - Vinyl

Table 16 - Exposure Ratings - Bleached Tar

Table 17 - Field Exposure Data - 18 months results according to coating type.

RESULTS AND DISCUSSION

The interpretation of the data is quite complex due to the number of coating systems involved, and the lack of consistent performance between the same generic types from different manufacturers. That is, all polyamide epoxies did not perform similarly. Therefore, when drawing conclusions between the U.S. and Japanese methodologies, it became necessary to assure that the methodology, and not the brand name, is responsible for the difference.

The conclusion according to generic type can be summarized as follows:

Coal Tar Epoxy

When comparing U.S. products applied according to both the U.S. and Japanese methodologies, the U.S. methodology was only equivalent to, or slightly better than, the Japanese methodology. Therefore, for this system, complete removal of the pre-construction primer does not appreciably improve results.

With regard to manufacturer differences, the U.S. and Japanese coatings appear to provide fairly comparable performance.

Polyamide Epoxy

The results of the U.S. versus Japanese methodology were inconsistent; one of the U.S. products showed better performance following the U.S. methodology, while the other showed poorer performance. Therefore, absolute conclusions regarding this system cannot be made.

Likewise, a comparison of U.S. and Japanese products showed mixed results with one U.S. and one Japanese product providing the best performance, and the remaining U.S. and Japanese products providing much poorer performance.

Inorganic Zinc

For one of the U.S. products, the U.S. methodology provided comparable performance to the Japanese methodology. For the remaining U.S. product, the U.S. methodology provided significantly better performance. Therefore, the U.S. methodology provides equivalent or better performance than the Japanese for this system.

With regard to coating systems, again the scatter of data between brand names too great to generalize on Japanese versus U.S. products (one U.S. and one Japanese product performed well, while the remaining U.S. and Japanese product showed lesser performance).

Chlorinated Rubber

For one of the U.S. products, the U.S. methodology provided slightly better performance, while for the other product, the U.S. methodology was significantly worse than the Japanese. Therefore, conclusions regarding the methodology are dependent upon the brand of the material tested.

With the exception of the poor performance of the U.S. methodology for one of the coating manufacturers, the U.S. and Japanese products appear to provide reasonably comparable performance.

Vinyl

Only one U.S. manufacturer supplied a vinyl coating. For this material, the U.S. methodology provided slightly lesser performance than the Japanese methodology.

With regard to coating manufacturers, the Japanese and U.S. products appear to provide comparable performance.

Bleached Tar

One U.S. supplier provided a bleached tar material for evaluation. Based on this material, the U.S. methodology provides better performance than the Japanese.

When comparing Japanese and U.S. products, the Japanese bleached tar provides better performance.

OVERALL CONCLUSIONS

The test results are summarized in tabular form below:

Coal Tax Epoxy	US-A	US Methodology slightly better than Japanese
	US-B	US Methodology equivalent to Japanese
Polyamide Epoxy	US-A	US Methodology slightly worse than Japanese
	US-B	US Methodology better than Japanese
Inorganic Zinc	US-A	US Methodology equivalent to Japanese
	US-B	US Methodology significantly better than Japanese
Chlorinated Rubber	US-A	US Methodology slightly better than Japanese
	US-B	US Methodology significantly worse than Japanese
Vinyl	US-A	US Methodology slightly worse than Japanese
Bleached Tar	US-B	US Methodology better than Japanese.

Briefly, the performance between methodologies is a function of the generic coating type and the particular brand of material tested. Despite these differences, from the laboratory accelerated tests, there does not appear to be a significant advantage in the complete removal of the pre-construction inorganic zinc primer followed by the application of a new zinc primer prior to the finish system. It is likely that the erratic (and in some cases poor) performance of the U.S. methodology is a result of the degree of cure of the inorganic zinc primer. The Japanese system utilized aged primer that is fully cured at the time of finish coating, while the U.S. utilizes fresh primer. An inorganic zinc primer that is marginally cured (even though acceptable from a recoat time standpoint) can reduce performance.

Inorganic zinc-rich primers cure through hydrolysis. Moisture enters into the reaction and liberates ethyl alcohol. This is necessary in order to form the zinc-silicate coating matrix. If a topcoat is applied before the zinc achieves proper cure, the accessibility of moisture to the film is substantially reduces, slowing down or conceivably stopping the cure mechanism at times. This can even occur when the manufacturers' recoat times are observed. The result can reduce strength and lntegrity of tne zinc primer, and subsequent performance.

This is believed to be the case here, even though the manufacturers' recoat times were observed. The inorganic zinc for U.S. Manufacturer A cured for 17 hours at approximately 60% RH prior to topcoating. The literature requires 16 hours at 55%. The primer for U.S. Manufacturer B cured for 96 hours at approximately 70% RH prior to topcoating. The literature requires 24 hours at 50% RH.

While the minimum times were observed in all cases, previous KTA studies have suggested that the minimum recoat times published by the manufacturers may be somewhat optimistic, and not allow complete curing to take place.

Figures 6 and 7 are possibly an example of adhesion problems associated with top coating over a coat of inorganic zinc primer before full cure. These figures (front & back) depict failure due to blistering after two weeks exposure to 150° salt water. The coating systems are two coats of chlorinated rubber over a full inorganic zinc primer coat. The methodology utilized in panel preparation and the coating supplier are U.S.

The Envirotest exposure was the lease severe of the test exposures utilized. Figures 8, 9, 10 and 11 demonstrate this. They represent the same Japanese material supplier and methodology. The system is a shop primer chlorinated rubber system. Figures 8, 9, 10 and 11 are representative of six months at 150°F salt water and the "Envirotest" exposure respectively. Note that edges, scribes and heat affected zones are the major areas of breakdown. This was representative of the majority of exposures.

Figures 12 and 13 demonstrate similar failure modes; film breakdown at edges and blistering along the heat affected zone. Back sides of both panels are shown. They are representative of the Japanese methodology and six month exposure at 150°F salt water immersion. Figure 12 is a polyamide epoxy and Figure 13 is a bleached tar epoxy both being Japanese materials.

The eighteen (18) month marine atmospheric exposures proved to be a mild environment with little coating breakdown occurring with any of the coatings or methods tested. When failure occurred at the edges, welds and scribes were the primary areas affected.

Coal tar epoxy and inorganic zinc performed very well independent of supplier, coating system or preparation method (Figures 14, 15, 16). The U.S. method of preparation provided superior protection for edges and welds independent of paint system (Figures 14, 15, 16).

FIGURE 6 - (front) Zinc\chlorinated rubber (U.S.) two weeks 150°F salt water.

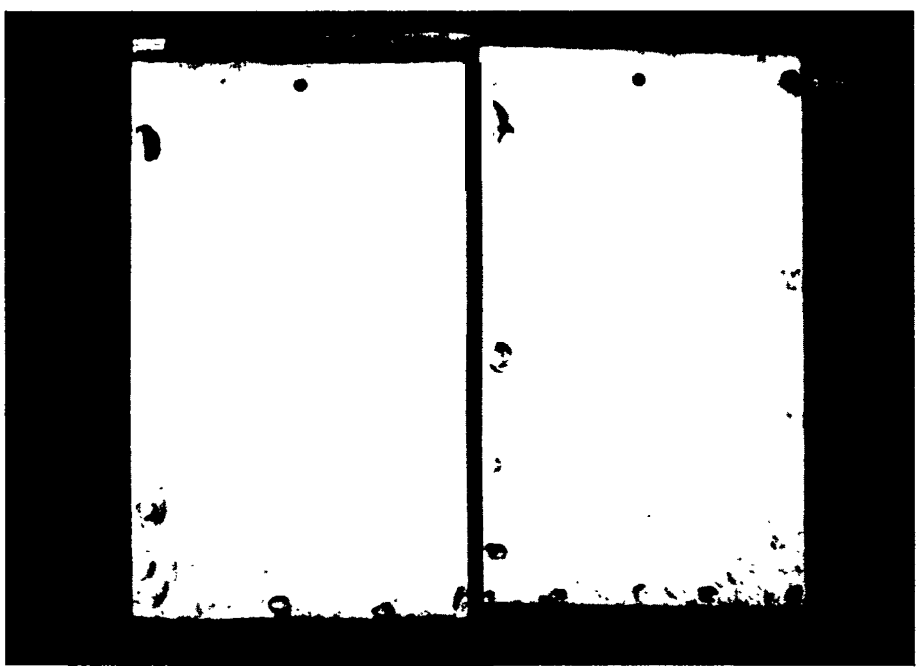


FIGURE 7 - (back) Zinc\chlorinated rubber (U.S.) two weeks 150°F salt water.

FIGURE 8 - (front) Japanese material & method.
Zinc/chlorinated rubber six months 150°F salt water.

FIGURE 9 - (back) Japanese material & method.
Zinc\chlorinated rubber six months 150°F salt water.

FIGURE 10 - (front) Japanese material & method.
Zinc/chlorinated rubber Enviortest.

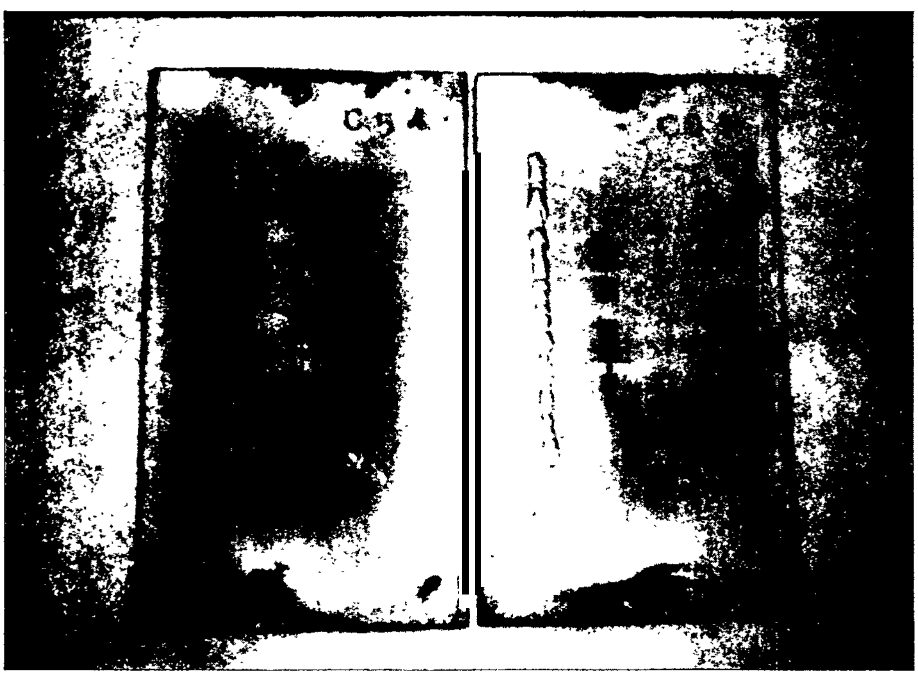


FIGURE 11 - (back) Japanese meaterial & method.
Zinc/chlorinated rubber Envirotest.

FIGURE 12 - (back) Japanese material & method.
Shop primer\polyamide epoxy six months 150°F salt water.

FIGURE 13 - (back) Japanese material & method.
Shop primer/bleached tar epoxy six months 150°F salt water.

FIGURE 14 - (U.S.) Coal/Tar Japanese method. 18 months Marine exposure.

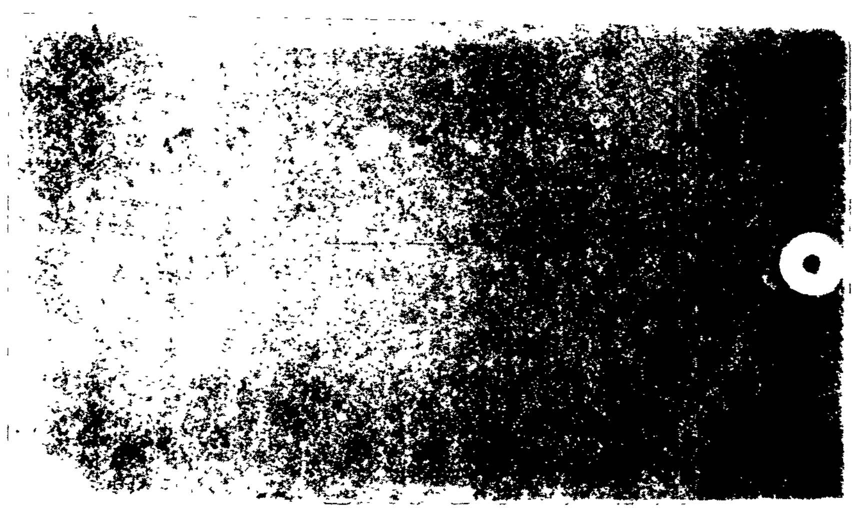


FIGURE 15 - (Jap.) Coal/Tar Japanese method. 18 months Marine exposure.

FIGURE 16 - (U.S.) Coal/Tar U.S. Method 18 months Marine Exposure.

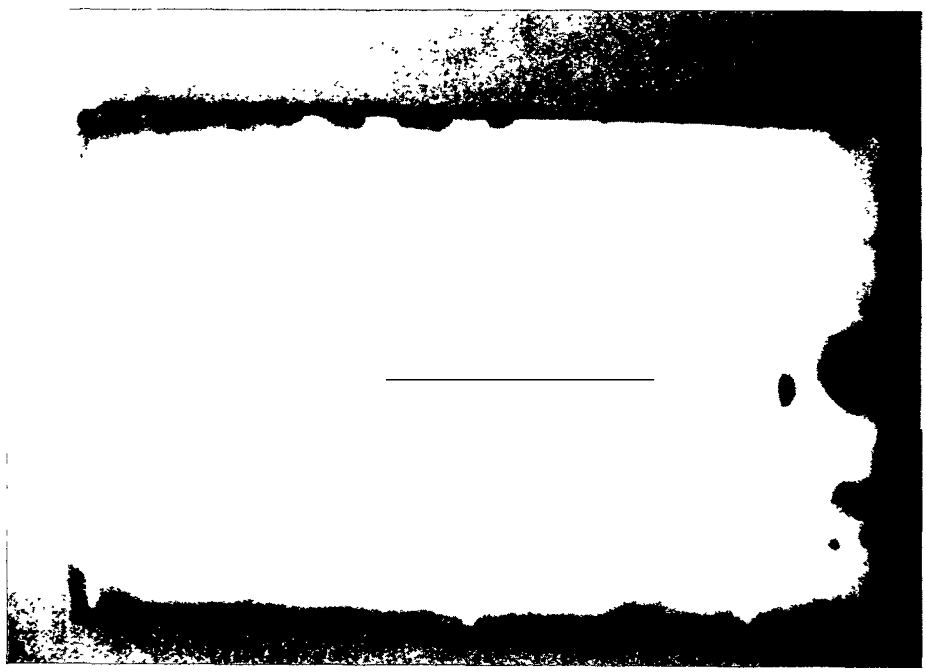
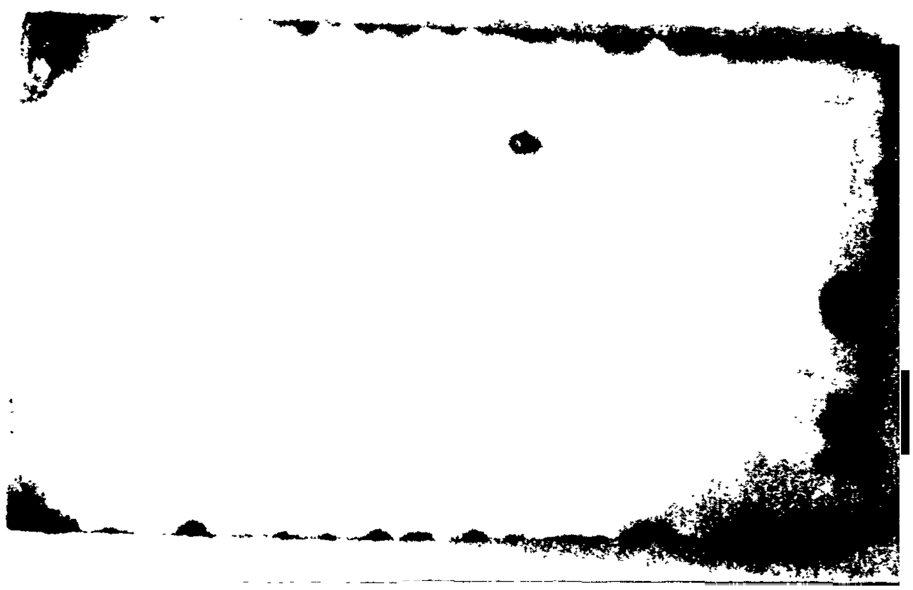


FIGURE 17 - (Jap.) Polyamide Epoxy Japanese method 18 months Marine exposure.



FUGURE 18 - (U.S.) Polyamide Epoxy Japanese method 18 months Marine exposure.

FIGURE 19 - (U. S.) Polyamide Expoxy U.S. Method 18 months Marine Exposure.

TABLES 2 - 5

Test Results - Blister/Corrosion Performance

The attached Tables 2 through 5 provide the actual test gradings for each coating system in the four accelerated test environments. The results are given for the front and back of the test panels (plane surfaces), heat effected zone (opposite the weld on panel backsides) , weld edges, and scribe. The raw data has been converted into a numerical rating (O-4) for each of the graded surfaces (e.g./ front, back, edges, etc.) . The basis for the grading is provided in the text of the report.

The tables included in this section are:

Table 2 - 2000 Hours Salt Fog - Test Results - Blistering\Corrosion

Table 3 - Sea Water Immersion at 150°F - Test Results - Blistering/Corrosion

Table 4 - 80 psi Head Pressure Cycling - Test Results - Blistering/Corrosion

Table 5 - KTA Envirotest - Test Results - Blistering/Corrosion

TABLE 2
2000 HOURS SALT FOG
TEST RESULTS - BLISTERING/CORROSION

	Meth.	Front Result	R	Back Result	R	Heat Effect Zone Result	R	Weld Result	R	Edge Result	R	Scribe Result	R
PRECON ZN/COAL TAR EPOXY	Jap.												
Japanese Mfg. A		None	4	None	4	None	4	None	4	Heavy rust	2	Heavy rust	2.5
Japanese Mfg. B		Sm patch B's	3.5	None	4	None	4	None	4	Heavy rust	2	4-#6; Lt. rust	2.5
U. S. Mfg. A		None	4	None	4	None	4	None	4	Heavy rust	2	Heavy rust	2
U. S. Mfg. B		None	4	None	4	None	4	None	4	Heavy rust	2	Heavy rust	2
PRE ZN/SP10/IOZ/COAL TR EP	U.S.												
U. S. Mfg. A		None	4	None	4	None	4	None	4	Heavy rust	2	Heavy rust	2
U. S. Mfg. B		None	4	None	4	None	4	None	4	Heavy rust	2	Heavy rust	2
PRECON ZN/POLYAMIDE EPOXY	Jap.												
Japanese Mfg. A		Sm patch B's	3.5	None	4	None	4	None	4	Heavy rust	2	2-#6; Hvy rst	1.5
Japanese Mfg. B		None	4	1/4"-3/4" B's	2	None	4	None	4	2F-2MD	0.5	2-#2; Hvy rust	1.5
U. S. Mfg. A		None	4	None	4	None	4	None	4	Heavy rust	2	Heavy rust	2
U. S. Mfg. B		6M	2.5	None	4	4M	2.5	None	4	2M-4M; Hvy rst	0.5	Heavy rust	2
PRE ZN/SP10/IOZ/POLY EPOX	U.S.												
U. S. Mfg. A		None	4	8M	3	None	4	None	4	Heavy rust	2	1/4-3/4; Hvy rst	1
U. S. Mfg. B		None	4	None	4	None	4	None	4	Heavy rust	2	Heavy rust; 4F	1.5
PRECON ZN/IOZ	Jap.												
Japanese Mfg. A		None	4	None	4	None	4	None	4	Heavy rust	2	None	4
Japanese Mfg. B		None	4	None	4	None	4	None	4	Heavy rust	2	Lt. rust	3
U. S. Mfg. A		None	4	None	4	None	4	None	4	Heavy rust	2	None	4
U. S. Mfg. B		None	4	None	4	None	4	Lt. rust	3.5	Heavy rust	2	Lt. rust	3
PRECON ZN/SP10/IOZ	U.S.												
U. S. Mfg. A		None	4	None	4	None	4	None	4	Heavy rust	2	None	4
U. S. Mfg. B		None	4	None	4	None	4	None	4	Heavy rust	2	None	4

Notes:
(1) Jap. Meth. - indicates primer incorporated into the protective coating system after minimal cleaning.
(2) U. S. Meth. - indicates primer removed by blast cleaning followed by the application of a new inorganic zinc primer and the remainder of the coating system.
(3) R - indicates the rating scale from 0 to 4.
(4) Number/Letter - indicates blister size/frequency designation per ASTM D 714.

TABLE 2 (Con't.)
2000 HOURS SALT FOG
TEST RESULTS - BLISTER/CORROSION

	Meth.	Front Result	R	Back Result	R	Heat Effect Zone Result	R	Weld Result	R	Edge Result	R	Scribe Result	R
PRECON ZN/CHLOR. RUBBER	Jap.												
Japanese Mfg. A		None	4	None	4	None	4	None	4	Heavy rust	2	Heavy rust	2
Japanese Mfg. B		None	4	8M (cluster)	3.5	None	4	8MD to 8D	2	Heavy rust	2	Heavy rust	2
U. S. Mfg. A		None	4	4F	3	8M	3	4MD	2	4MD; Hvy rust	0.5	Heavy rust	2
U. S. Mfg. B		4F with PPR	2.5	None	4	6F	3	4F	3	Heavy rust	2	Heavy rust	2
PRE ZN/SP10/IOZ/CHL RUB	U.S.												
U. S. Mfg. A		None	4	None	4	None	4	None	4	Heavy rust	2	Heavy rust	2
U. S. Mfg. B		2M to >2MD	0.5	2F to 2M bot.	2.5	None	4	None	4	Heavy rust	2	None	4
PRECON ZN/VINYL	Jap.												
Japanese Mfg. A		None	4	None	4	None	4	6F-6M; rust	1.5	Heavy rust	2	Heavy rust	2
Japanese Mfg. B		None	4	None	4	None	4	4F to 4M	2.5	2MD; Hvy rust	0.5	4M-2M; Hvy rst	0.5
U. S. Mfg. A		None	4	None	4	8M	3	6M-8MD; rust	1.5	6F; Heavy rust	1	Heavy rust	2
PRECON ZN/SP10/IOZ/VINYL	U.S.												
U. S. Mfg. A		None	4	None	4	3/4"-1" B's	0.5	None	4	Lrg B's;Hvy rst	0.5	Heavy rust	2
PRECON ZN/BLEACHED TAR	Jap.												
Japanese Mfg. A		None	4	None	4	None	4	None	4	Heavy rust	2	Heavy rust	2
Japanese Mfg. B		None	4	None	4	8F to 8M	3	None	4	Heavy rust	2	Heavy rust; 2F	1.0
U. S. Mfg. B		None	4	None	4	9D	2	None	4	Heavy rust	2	Heavy rust; 6F	1.5
PRE ZN/SP10/IOZ/BLCH TAR	U.S.												
U. S. Mfg. B		None	4	None	4	None	4	None	4	Heavy rust	2	Heavy rust; 4F	1.5

Notes:
(1) Jap. Meth. - indicates primer incorporated into the protective coating system after minimal cleaning.
(2) U. S. Meth. - indicates primer removed by blast cleaning followed by the application of a new inorganic zinc primer and the remainder of the coating system.
(3) R - indicates the rating scale from 0 to 4.
(4) Number/Letter - indicates blister size/frequency designation per ASTM D 714.

TABLE 3
SEA WATER IMMERSION AT 150°F
TEST RESULTS - BLISTERING/CORROSION

	Meth.	Front Result	R	Back Result	R	Heat Effect Zone Result	R	Weld Result	R	Edge Result	R	Scribe Result	R
PRECON ZN/COAL TAR EPOXY	Jap.												
Japanese Mfg. A		2M to 8M	2	2M to 8M	2	None	4	6F	3	Lt. rust	3	1-1" B	2.5
Japanese Mfg. B		4M to 6MD	2	None	4	6F	3	8M	3	Lt. rust	3	Lt. rust	3
U. S. Mfg. A		None	4	2F to 2M	2	None	4	2F to 2M	2	Lt. rust	3	None	4
U. S. Mfg. B		2M to 6MD	2	6F to 6M	2.5	6M	2.5	None	4	Lt. rust	3	None	4
PRE ZN/SP10/IOZ/COAL TR EP	U.S.												
U. S. Mfg. A		None	4	None	4	1-1/4" B	3.5	None	4	Lt. rust; 2F	2.5	None	4
U. S. Mfg. B		2M to 6M	2	2M to 6M	2	None	4	None	4	Lt. rust	3	None	4
PRECON ZN/POLYAMIDE EPOXY	Jap.												
Japanese Mfg. A		6MD to 6D	1	6F to 6M (bot)	3	None	4	None	4	Lt. rust	3	Lt. rust	3
Japanese Mfg. B						Pulled From Test After 3 Month Grading							
U. S. Mfg. A		6M to 6MD	2	6M - Rt. side	3	6M	2.5	None	4	Lt. rust; 2F	2.5	None	3
U. S. Mfg. B		2M to 4MD	2	4MD - 6MD	2	2M	2	2M	2	Lt. rust	3	None	4
PRE ZN/SP10/IOZ/POLY EPOX	U.S.												
U. S. Mfg. A		2F to 2M	2	2F	2.5	None	4	None	4	Lt. rust	3	Lt. rust; 2M	2.5
U. S. Mfg. B		8M & 6-3/4" B's	2	8M-6D;2-1" B's	1	None	4	None	4	Lt. rust	3	6D	1
PRECON ZN/IOZ	Jap.												
Japanese Mfg. A		None	4	None	4	None	4	6M to 2F	2.5	Lt. rust	3	None	4
Japanese Mfg. B		None	4	None	4	2MD	1	2D to 4MD	1	Lt. rust	3	Lt. rust	3
U. S. Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	Lt. rust	3
U. S. Mfg. B		4D	1	4D	1	None	4	None	4	Lt. rust	3	None	4
PRECON ZN/SP10/IOZ	U.S.												
U. S. Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	Lt. rust	3
U. S. Mfg. B		None	4	None	4	None	4	None	4	Lt. rust	3	None	4

Notes: (1) Jap. Meth. - indicates primer incorporated into the protective coating system after minimal cleaning.
(2) U. S. Meth. - indicates primer removed by blast cleaning followed by the application of a new inorganic zinc primer and the remainder of the coating system.
(3) R - indicates the rating scale from 0 to 4.
(4) Number/Letter - indicates blister size/frequency designation per ASTM D 714.

TABLE 3 (Con't.)
SEA WATER IMMERSION AT 150°F
TEST RESULTS - BLISTERING/CORROSION

	Meth.	Front Result	R	Back Result	R	Heat Effect Zone Result	R	Weld Result	R	Edge Result	R	Scribe Result	R
PRECON ZN/CHLOR. RUBBER	Jap.												
Japanese Mfg. A		6F to 8MD	2.5	None	4	2F to 6MD	2	6D	1	Lt. rust; 6MD	2	None	4
Japanese Mfg. B		8M to 8MD	2.5	6F to 8MD	2.5	None	4	6MD	2	Lt. rust	3	None	4
U. S. Mfg. A		4D	1	4D	1	None	4	None	4	Lt. rust	3	Lt. rust	3
U. S. Mfg. B		6MD	2	6MD	2	4MD	2	None	4	Lt. rust	3	None	4
PRE ZN/SP10/IOZ/CHL RUB	U.S.												
U. S. Mfg. A		4M to 4D	1	4M to 4D	1	None	4	None	4	Lt. rust	3	Lt. rust	3
U. S. Mfg. B		Pulled From Test After 3 Month Grading											
PRECON ZN/VINYL	Jap.												
Japanese Mfg. A		8MD	2.5	6M to 8M	2.5	4M	2.5	None	4	Lt. rust	3	Lt. rust	3
Japanese Mfg. B		4F to 8M	3	8M	3	8MD	2.5	None	4	Lt. rust	3	8D	2
U. S. Mfg. A		8M	3	None	4	8F to 8M	3	None	4	Lt. rust	3	None	4
PRECON ZN/SP10/IOZ/VINYL	U.S.												
U. S. Mfg. A		2MD to 8D	1	2MD to 8D	1	None	4	None	4	Lt. rust	3	Lt. rust	3
PRECON ZN/BLEACHED TAR	Jap.												
Japanese Mfg. A		4F to 8M	3	4F to 4M	2.5	None	4	None	4	Lt. rust	3	Lt. rust	3
Japanese Mfg. B		2M-6M, 2-1"crk	2	None	4	None	4	None	4	Lt. rust	3	Lt. rust	3
U. S. Mfg. B		4D; 12--1" Bs	1	4D	1	1/2 to 6" B	1	None	4	Lt. rust	3	None	4
PRE ZN/SP10/IOZ/BLCH TAR	U.S.												
U. S. Mfg. B		2MD (top)	2	2M (top)	2.5	None	4	None	4	Lt. rust	3	6M	2.5

Notes:
(1) Jap. Meth. - indicates primer incorporated into the protective coating system after minimal cleaning.
(2) U. S. Meth. - indicates primer removed by blast cleaning followed by the application of a new inorganic zinc primer and the remainder of the coating system.
(3) R- indicates the rating scale from 0 to 4.
(4) Number/Letter - indicates blister size/frequency designation per ASTM D 714.

TABLE 4
80 psi **HEAD PRESSURE** CYCLING
TEST RESULTS - BLISTERING/CORROSION

	Meth.	Front Result	R	Back Result	R	Heat Effect Zone Result	R	Weld Result	R	Edge Result	R	Scribe Result	R
PRECON ZN/COAL TAR EPOXY	Jap.												
Japanese Mfg. A		None	4	None	4	None	4	8F	3.5	Lt. rust	3	6F	3
Japanese Mfg. B		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
U. S. Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
U. S. Mfg. B		None	4	None	4	None	4	None	4	Lt. rust	3	6F to 4M	2.5
PRE ZN/SP10/IOZ/COAL TR EP	U.S.												
U. S. Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	6F	3
U. S. Mfg. B		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
PRECON ZN/POLYAMIDE EPOXY	Jap.												
Japanese Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
Japanese Mfg. B		None	4	None	4	None	4	None	4	Lt. rust	3	6F	3
U. S. Mfg. A		None	4	None	4	None	4	None	4	8M; Lt. rust	2.5	None	4
U. S. Mfg. B		4F to 4M	2.5	6F to 6M	2.5	None	4	None	4	Lt. rust	3	None	4
PRE ZN/SP10/IOZ/POLY EPOX	U.S.												
U. S. Mfg. A		4F and 8M	3.0	9MD	2.5	None	4	None	4	Lt. rust	3	None	4
U. S. Mfg. B		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
PRECON ZN/IOZ	Jap.												
Japanese Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
Japanese Mfg. B		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
U. S. Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
U. S. Mfg. B		4M to 6MD	2.0	4M to 6M	2.5	None	4	None	4	Lt. rust	3	None	4
PRECON ZN/SP10/IOZ	U.S.												
U. S. Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
U. S. Mfg. B		None	4	None	4	None	4	None	4	Lt. rust	3	None	4

Notes:
(1) **Jap. Meth. -** indicates primer incorporated into the protective coating system after minimal cleaning.
(2) **U. S. Meth. -** indicates primer removed by blast cleaning followed bY the application of a new inorganic zinc primer 11and the remainder of the coating system.
(3) R - indicates the rating scale from 0 to 4.
(4) **Number/Letter -** indicates blister size/frequency designation Per ASTM D 714.

TABLE 4 (Con't.)

80 psi HEAD PRESSURE CYCLING

TEST RESULTS - BLISTERING/CORROSION

	Meth.	Front Result	R	Back Result	R	Heat Effect Zone Result	R	Weld Result	R	Edge Result	R	Scribe Result	R
PRECON ZN/CHLOR. RUBBER	Jap.												
Japanese Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
Japanese Mfg. B		None	4	9F	3.5	None	4	None	4	Lt. rust	3	9F	3.5
U. S. Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
U. S. Mfg. B		None	4	4F	3	None	4	None	4	Lt. rust	3	2F	2.5
PRE ZN/SPIO/IOZ/CHL RUB	U.S.												
U. S. Mfg. A		None	4	None	4	None	4	None	4	4F; Lt. rust	2.5	9F	3.5
U. S. Mfg. B		2MD & Larger	0.5	2MD	1	None	4	None	4	Lt. rust	3	None	4
PRECON ZN/VINYL	Jap.												
Japanese Mfg. A								6F	3	Lt. rust	3	None	4
Japanese Mfg. B								None	4	Lt. rust	3	8F	3.5
U. S. Mfg. A								8D	2	Lt. rust	3	None	4
PRECON ZN/SPIO/IOZ/VINYL	U.S.												
U. S. Mfg. A		None	4	4F	3	None	4	None	4	Lt. rust	3	8F	3.5
PRECON ZN/BLEACHED TAR	Jap.												
Japanese Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	6F	3
Japanese Mfg. B		None	4	None	4	8MD	2.5	None	4	Lt. rust	3	8F to 9M	3
U. S. Mfg. B		None	4	4F	3	8M	3	None	4	Lt. rust	3	4M to 6M	2.5
PRE ZN/SPIO/IOZ/BLCH TAR	U.S.												
U. S. Mfg. B		None	4	None	4	None	4	None	4	Lt. rust	3	None	14

Notes:
(1) Jap. Meth. - indicates primer incorporated into the protective coating system after minimal cleaning.
(2) U. S. Meth. - indicates primer removed by blast cleaning followed by the application of a new inorganic zinc primer and the remainder of the coating system.
(3) R - indicates the rating scale from 0 to 4.
(4) Number/Letter - indicates blister size/frequency designation per ASTM D 714.

TABLE 5
KTA ENVIROTEST
TEST RESULTS - BLISTERING/CORROSION

	Meth.	Front Result	R	Back Result	R	Heat Effect Zone Result	R	Weld Result	R	Edge Result	R	Scribe Result	R
PRECON ZN/COAL TAR EPOXY	Jap.												
Japanese Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	Lt. rust	3
Japanese Mfg. B		None	4	None	4	None	4	None	4	Lt. rust	3	Lt. rust	3
U. S. Mfg. A		None	4	None	4	6F to 8F	3	None	4	Lt. rust	3	4F	3
U. S. Mfg. B		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
PRE ZN/SP10/IOZ/COAL TR EP	U.S.												
U. S. Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
U. S. Mfg. B		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
PRECON ZN/POLYAMIDE EPOXY	Jap.												
Japanese Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	Lt. rust	3
Japanese Mfg. B		None	4	None	4	None	4	None	4	Lt. rust	3	Lt. rust	3
U. S. Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
U. S. Mfg. B		Rust (8-9)	3	None	4	None	4	None	4	Lt. rust	3	6F	3
PRE ZN/SP10/IOZ/POLY EPOX	U.S.												
U. S. Mfg. A		9F	3.5	9F	3.5	None	4	None	4	Lt. rust	3	None	4
U. S. Mfg. B		Rust (9)	3.5	None	4	None	4	None	4	Lt. rust	3	6F	3
PRECON ZN/IOZ	Jap.												
Japanese Mfg. A		None	4	None	4	None	4	Rust (6)	2.5	Lt. rust	3	Lt. rust	3
Japanese Mfg. B		Rust (7)	2.5	None	4	None	4	Moderate rust	2.5	Lt. rust	3	Lt. rust	3
U. S. Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
U. S. Mfg. B		None	4	None	4	6M to 8M	2.5	None	4	Lt. rust	3	None	4
PRECON ZN/SP10/IOZ	U.S.												
U. S. Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
U. S. Mfg. B		Rust (6-7)	2.5	None	4	None	4	None	4	Lt. rust	3	None	4

Notes: (1) Jap. Meth. - indicates primer incorporated into the protective coating system after minimal cleaning.
(2) U. S. Meth. - indicates primer removed by blast cleaning followed by the application of a new inorganic zinc primer and the remainder of the coating system.
(3) R - indicates the rating scale from 0 to 4.
(4) Number/Letter - indicates blister size/frequency designation per ASTM D 714.

TABLE 5 (Con't.)
KTA ENVIROTEST
TEST RESULTS - BLISTERING/CORROSION

	Meth.	Front Result	R	Back Result	R	Heat Effect Zone Result	R	Weld Result	R	Edge Result	R	Scribe Result	R
PRECON ZN/CHLOR. RUBBER	Jap.												
Japanese Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	Lt. rust	3
Japanese Mfg. B		Rust (7-9)	2.5	None	4	None	4	Rust (8)	3	Lt. rust	3	Lt. rust	3
U. S. Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
U. S. Mfg. B		None	4	4F	3	None	4	None	4	Lt. rust	3	4F to 6F	3
PRE ZN/SP10/IOZ/CHL RUB	U.S.												
U. S. Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
U. S. Mfg. B		4M	2.5	4F to 4M	2.5	None	4	None	4	Lt. rust	3	None	4
PRECON ZN/VINYL	Jap.												
Japanese Mfg. A		None	4	None	4	None	4	Rust (8)	3	Lt. rust	3	Lt. rust	3
Japanese Mfg. B		Rust (8)	3	None	4	None	4	Rust - 3 spots	3.5	Lt. rust	3	Lt. rst. 4F B's	2.5
U. S. Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
PRECON ZN/SP10/IOZ/VINYL	U.S.												
U. S. Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	None	4
PRECON ZN/BLEACHED TAR	Jap.												
Japanese Mfg. A		None	4	None	4	None	4	None	4	Lt. rust	3	Lt. rust	3
Japanese Mfg. B		None	4	None	4	None	4	Rust (9)	3.5	Lt. rust	3	Lt. rust	3
U. S. Mfg. B		None	4	None	4	None	4	None	4	Lt. rust	3	6F to 8F	3
PRE ZN/SP10/IOZ/BLCH TAR	U.S.												
U. S. Mfg. B		Rust (7-9)	2.5	None	4	None	4	None	4	Lt. rust	3	None	4

Notes: (1) Jap. Meth. - indicates primer incorporated into the protective coating system after minimal cleaning.
(2) U. S. Meth. - indicates primer removed by blast cleaning followed by the application of a new inorganic zinc primer and the remainder of the coating system.
(3) R - indicates the rating scale from 0 to 4.
(4) Number/Letter - indicates blister size/frequency designation per ASTM D 714.

TABLES 6 - 10 SYSTEM RATINGS

The raw data gradings from Tables 2 through 5 have been combined to arrive at a numerical system rating number from 0 to 31 (0 - worst; 31 - best). This allows for the direct comparison of the performance of the respective coating systems and methodologies in each test environment.

System Code

A code has been used to identify the coating manufacturers and methodologies employed;

- J - Japanese Manufacturer A (Japanese Methodology)
- J - Japanese Manufacturer B (Japanese Methodology)
- U - U.S. Manufacturer A (Japanese Methodology)
- U - U.S. Manufacturer A (U.S. Methodology)
- U - U.S. Manufacturer B (Japanese Methodology)
- U - U.S. Manufacturer B (U.S. Methodology)

Tables

The tables included in this section are:

Table 6 - System Rating - KTA Envirotest

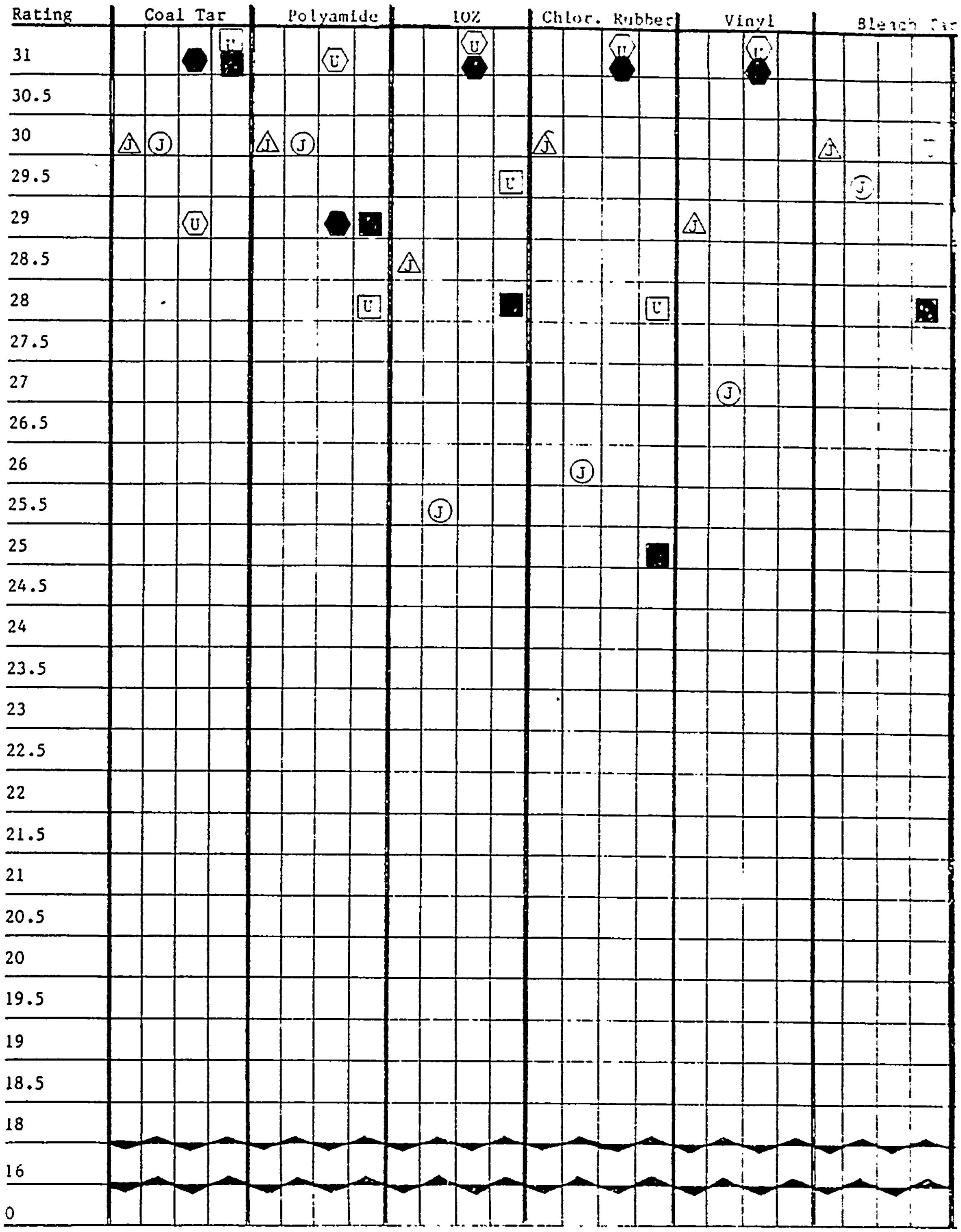
Table 7 - System Rating - 80 psi Pressurized/ Repressurized Cycle

Table 8 - System Rating - Salt Fog

Table 9 - System Rating - Sea Water Immersion at 150°F

Table 10 - Average System Rating - Combined Test Exposures

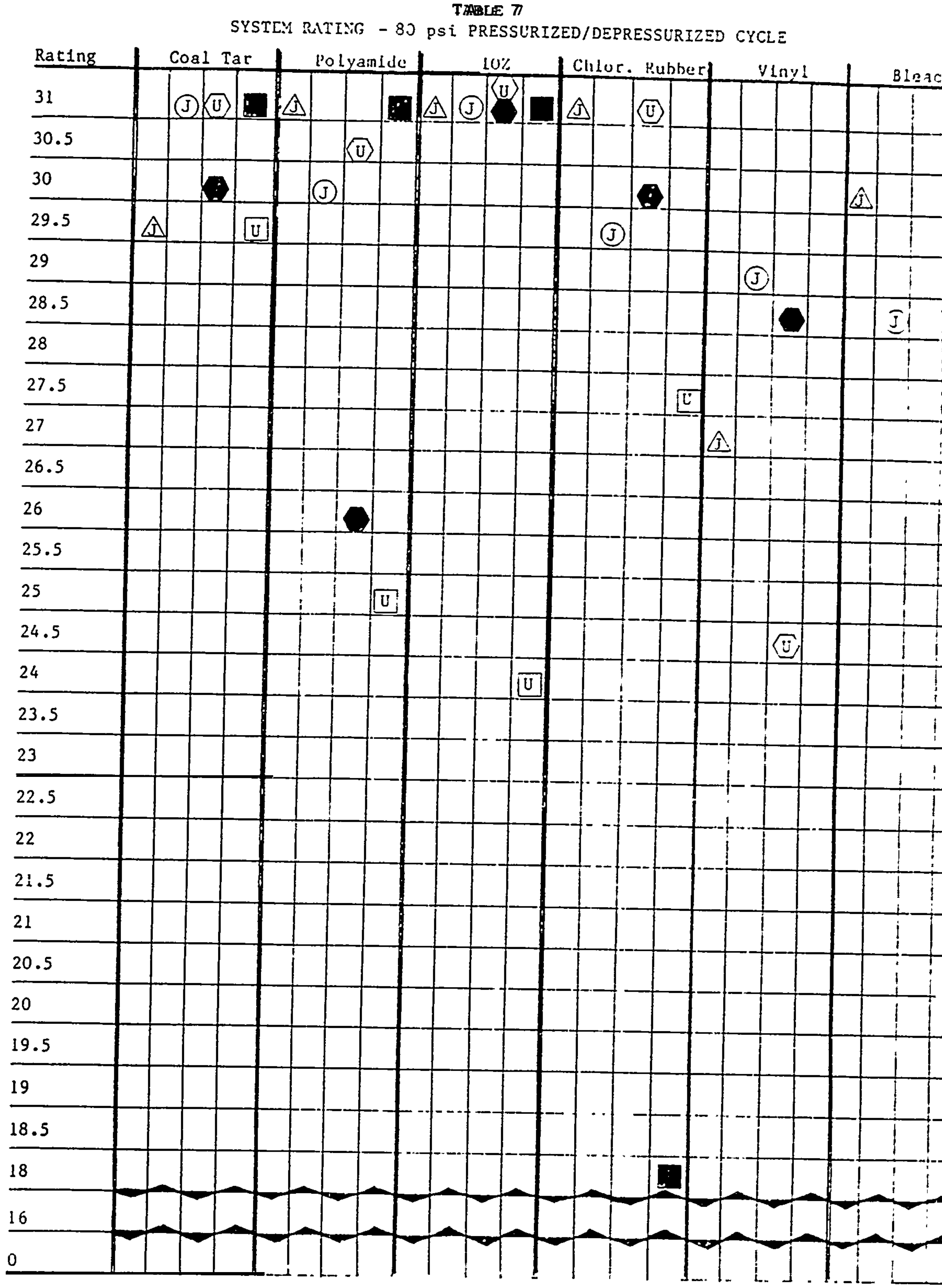
TABLE 6
SYSTEM RATISG -KTA ENVIROTEST



KEY:
J (triangle) - Japanese Manufacturer A (Japanese Methodology)
J (circle) - Japanese Manufacturer B (Japanese Methodology)
U (hexagon) - U.S. Manufacturer A (Japanese Methodology)
(filled hexagon) - U.S. Manufacturer A (U.S. Methodology)
U (square) - U.S. Manufacturer B (Japanese Methodology)
(filled square) - U.S. Manufacturer B (U.S. Methodology)

TABLE 7

SYSTEM RATING - 80 psi PRESSURIZED/DEPRESSURIZED CYCLE



KEY:

J - Japanese Manufacturer A (Japanese Methodology)

J - Japanese Manufacturer B (Japanese Methodology)

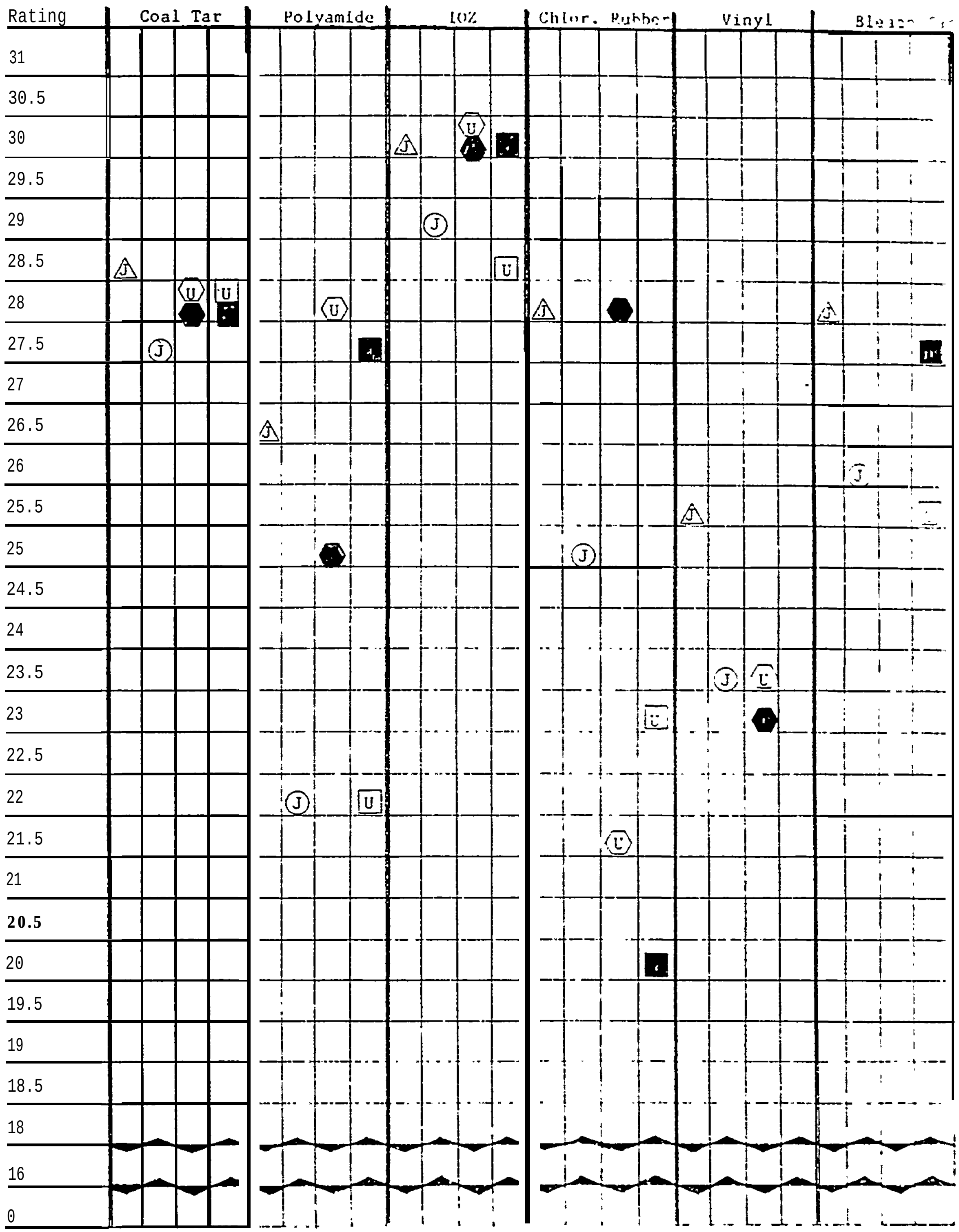
U - U.S. Manufacturer A (Japanese Methodology)

U.S. Manufacturer A (U.S. Methodology)

U - U.S. Manufacturer B (Japanese Methodology)

U.S. Manufacturer B (U.S. Methodology)

TABLE 8
SYSTEM RATING - SALT FOG



KEY: (J in triangle) - Japanese Manufacturer A (Japanese Methodology)

(J in circle) - Japanese Manufacturer B (Japanese Methodology)

(U in hexagon) - U.S. Manufacturer A (Japanese Methodology)

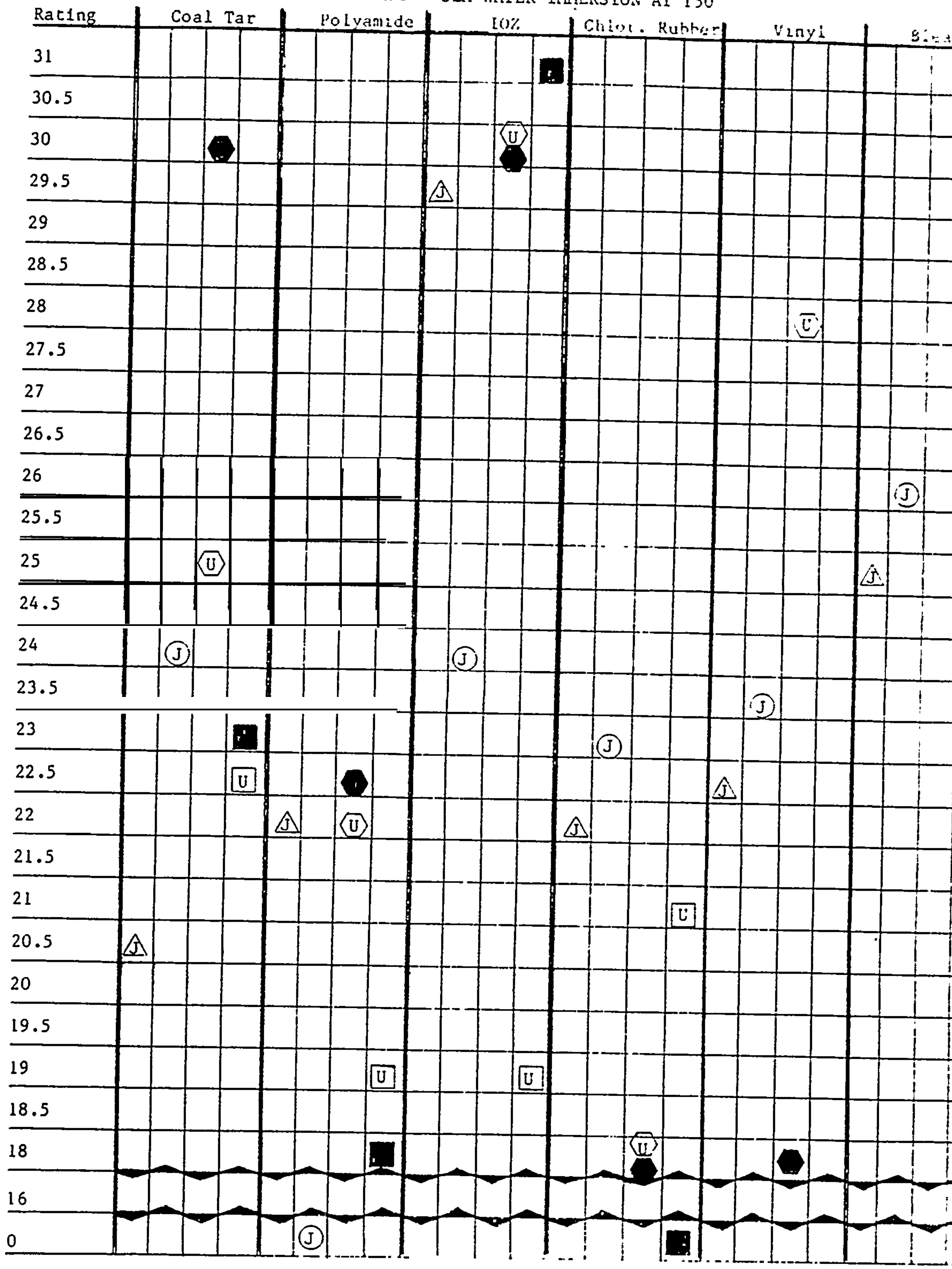
(filled hexagon) - U.S. Manufacturer A (U.S. Metethodology)

(U in square) - U.S. Manufacturer B (Japanese Methodology)

(filled square) - U.S. Manufacturer B (U.S. Methodology)

TABLE 9

SYSTEM RATING - SEA WATER IMMERSION AT 150°

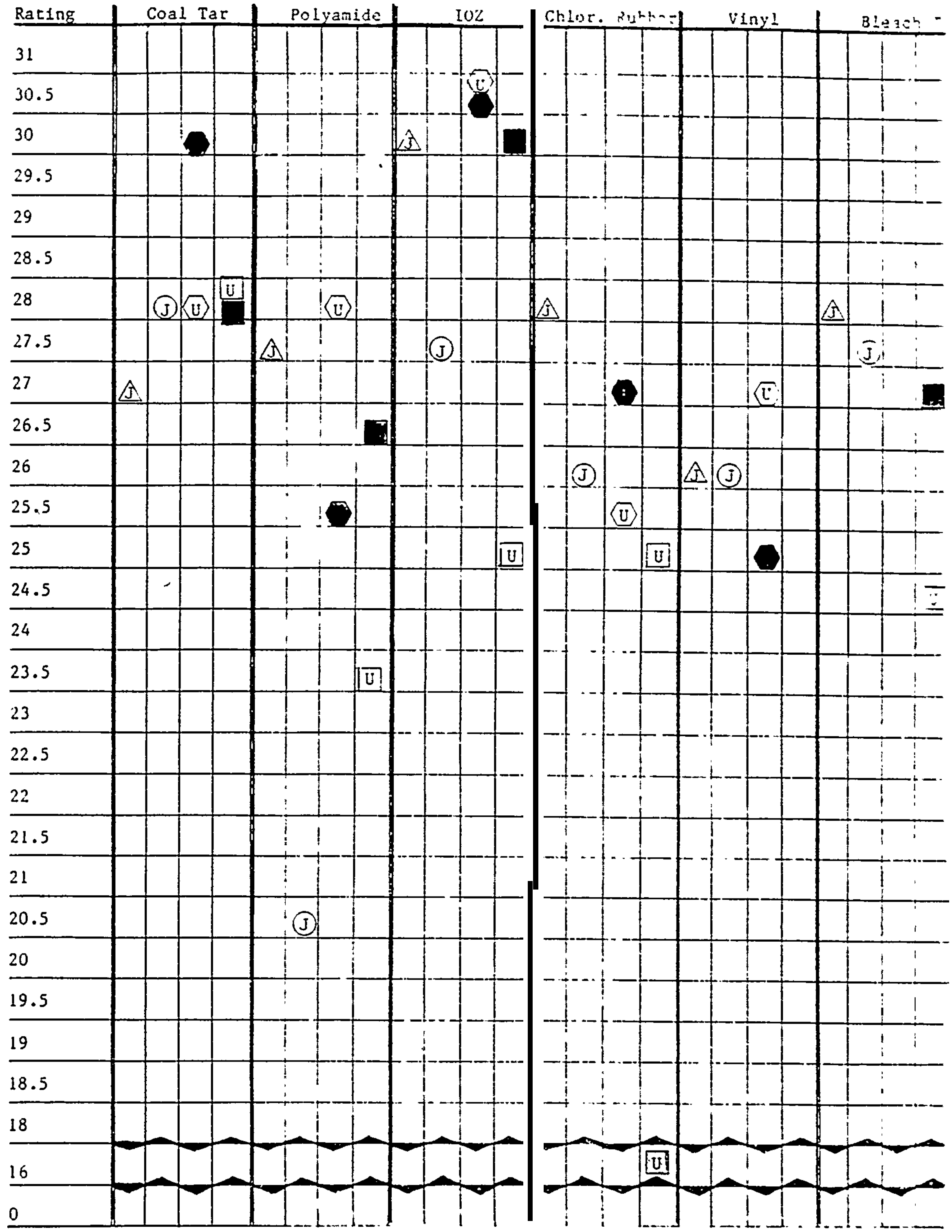


KEY:

- J (triangle) – Japanese Manufacturer A (Japanese Methodology)
- J (circle) – Japanese Manufacturer B (Japanese Methodology)
- U (hexagon) – U.S. Manufacturer A (Japanese Methodology)
- (filled hexagon) – U.S. Manufacturer A (U.S. Methodology)
- U (square) – U.S. Manufacturer B (Japanese Methodology)
- (filled square) – U.S. Manufacturer B (U.S. Methodology)

TABLE 10

AVERAGE SYSTEM RATINGS - COMBINED TEST EXPOSURES



KEY:
- (J) triangle – Japanese Manufacturer A (Japanese Methodology)
- (J) circle – Japanese Manufacturer B (Japanese Methodology)
- (U) hexagon – U.S. Manufacturer A (Japanese Methodology)
- solid hexagon – U.S. Manufacturer A (U.S. Methodology)
- (U) square – U.S. Manufacturer B (Japanese Methodology)
- solid square – U.S. Manufacturer B (U.S. Methodology)

TABLES 11 - 16 - EXPOSURE RATINGS

These tables reorganize the coating system performance according to the coating type, rather than the test exposure. That is, the performance of the coal tar epoxy systems, for example, in each of the test environments is presented on a single page. The average performance in the combined laboratory accelerated tests is presented in the last column.

System Code

A code has been developed to identify the coating manufacturers and methodologies employed;

J - Japanese Manufacturer A (Japanese Methodology)

J - Japanese Manufacturer B (Japanese Methodology)

U - U.S. Manufacturer A (Japanese Methodology)

U - U.S. Manufacturer A (U.S. Methodology)

U - U.S. Manufacturer B (Japanese Methodology)

U - U.S. Manufacturer B (U.S. Methodology)

Tables

The tables included in this section are:

Table 11 - Exposure Ratings - Coal Tar Epoxy

Table 12 - Exposure Ratings - Polyamide Epoxy

Table 13 - Exposure Ratings - Inorganic Zinc

Table 14 - Exposure Ratings - Chlorinated Rubber

Table 15 - Exposure Ratings - Vinyl

Table 16 - Exposure Ratings - Bleached Tar

TABLE 11
EXPOSURE RATINGS - COAL TAR EPOXY

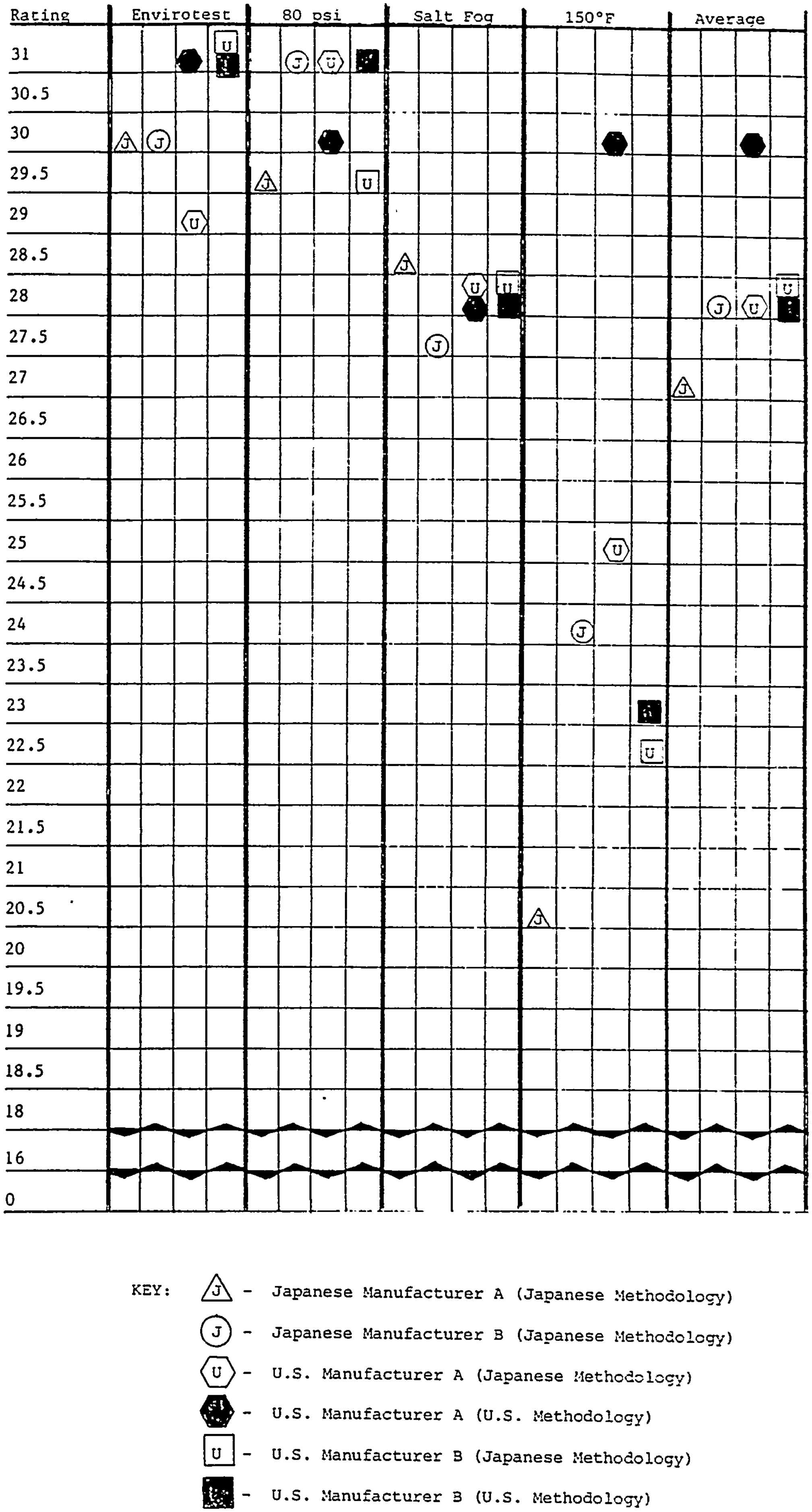
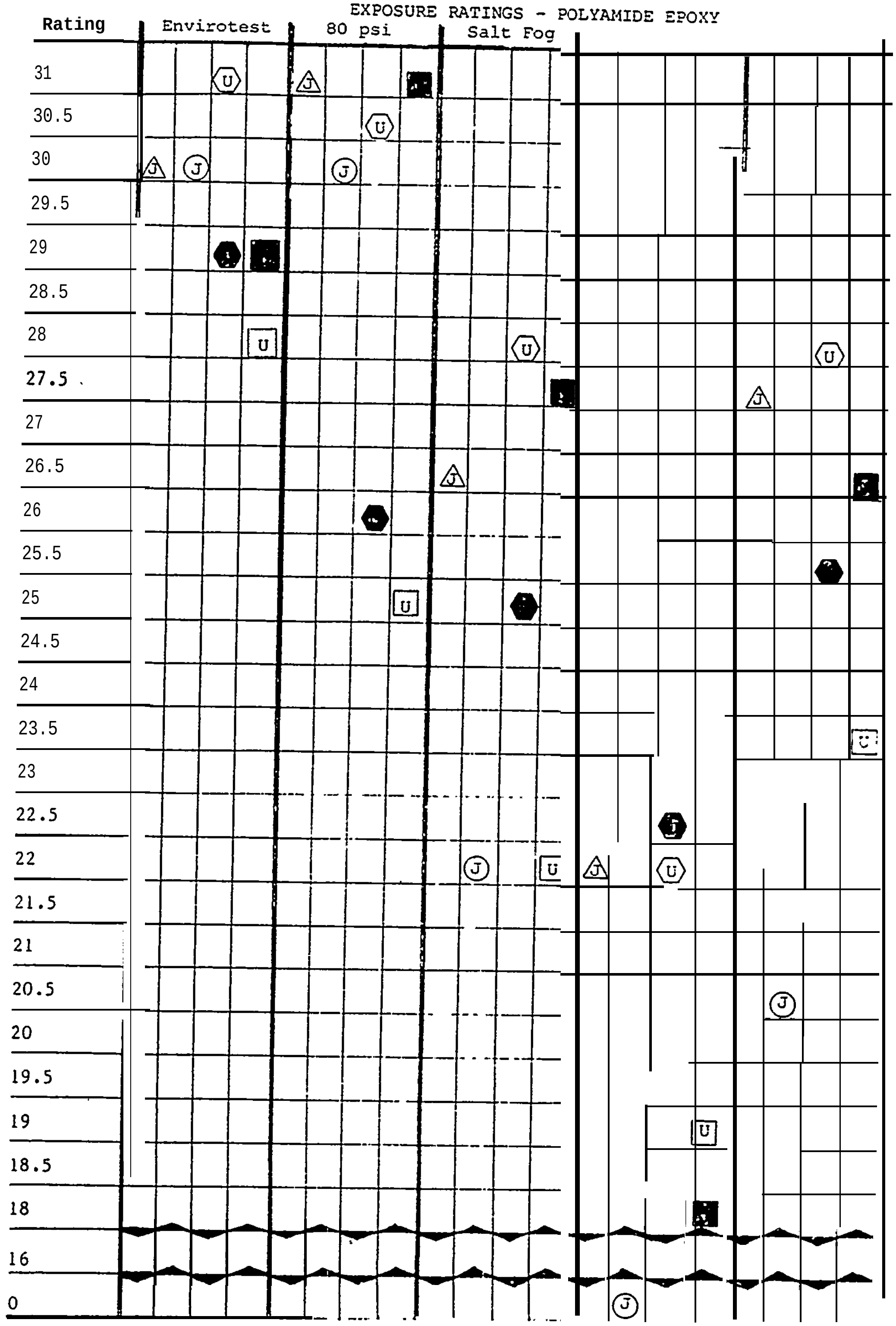


TABLE 12

EXPOSURE RATINGS - POLYAMIDE EPOXY



KEY: J (triangle) - Japanese Manufacturer A (Japanese Methodology)

J (circle) - Japanese Manufacturer B (Japanese Methodology)

U (hexagon) - U.S. Manufacturer A (Japanese Methodology)

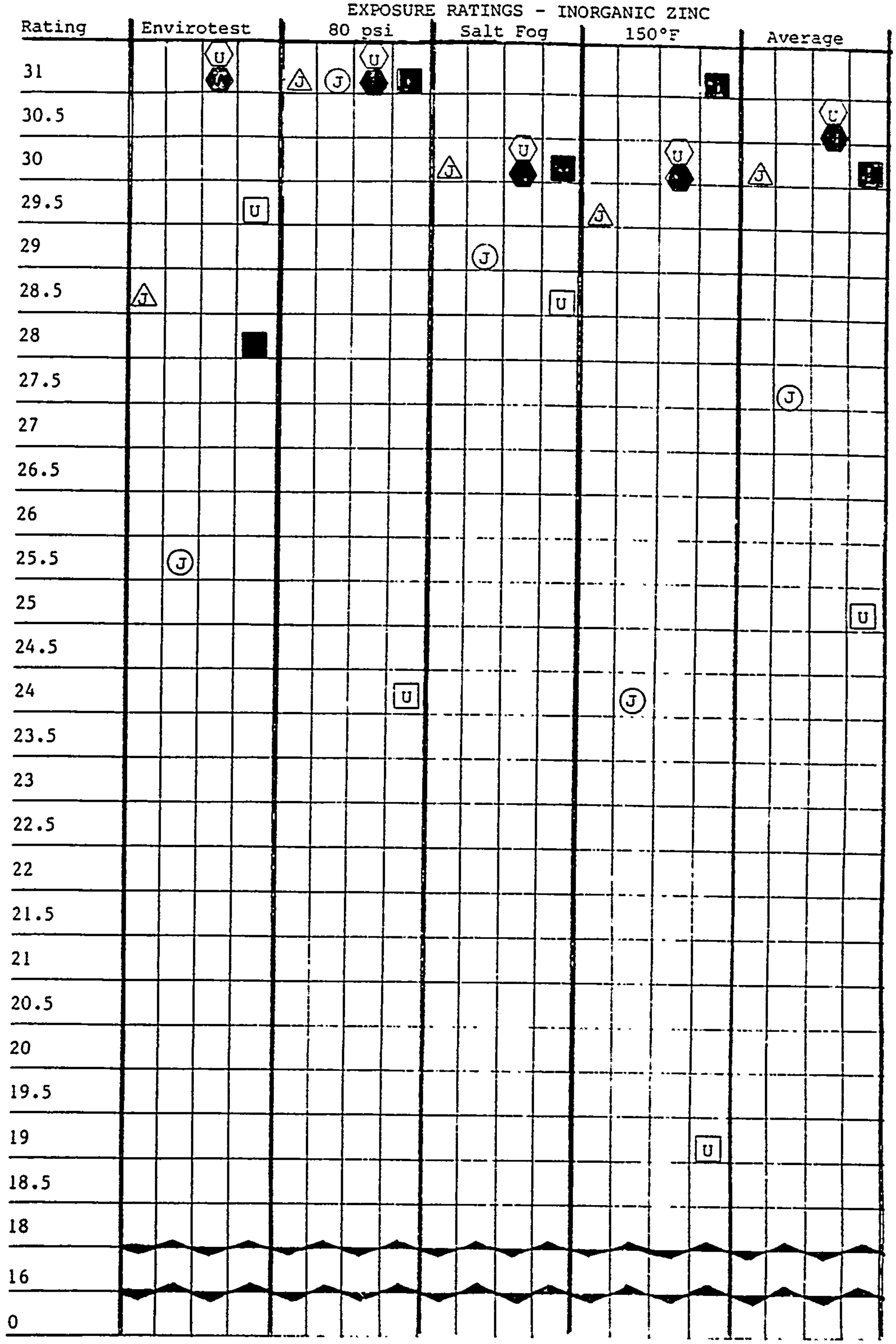
(filled hexagon) - U.S. Manufacturer A (U.S. Methodology)

U (square) - U.S. Manufacturer B (Japanese Methodology)

(filled square) - U.S. Manufacturer B (U.S. Methodology)

TABLE 13

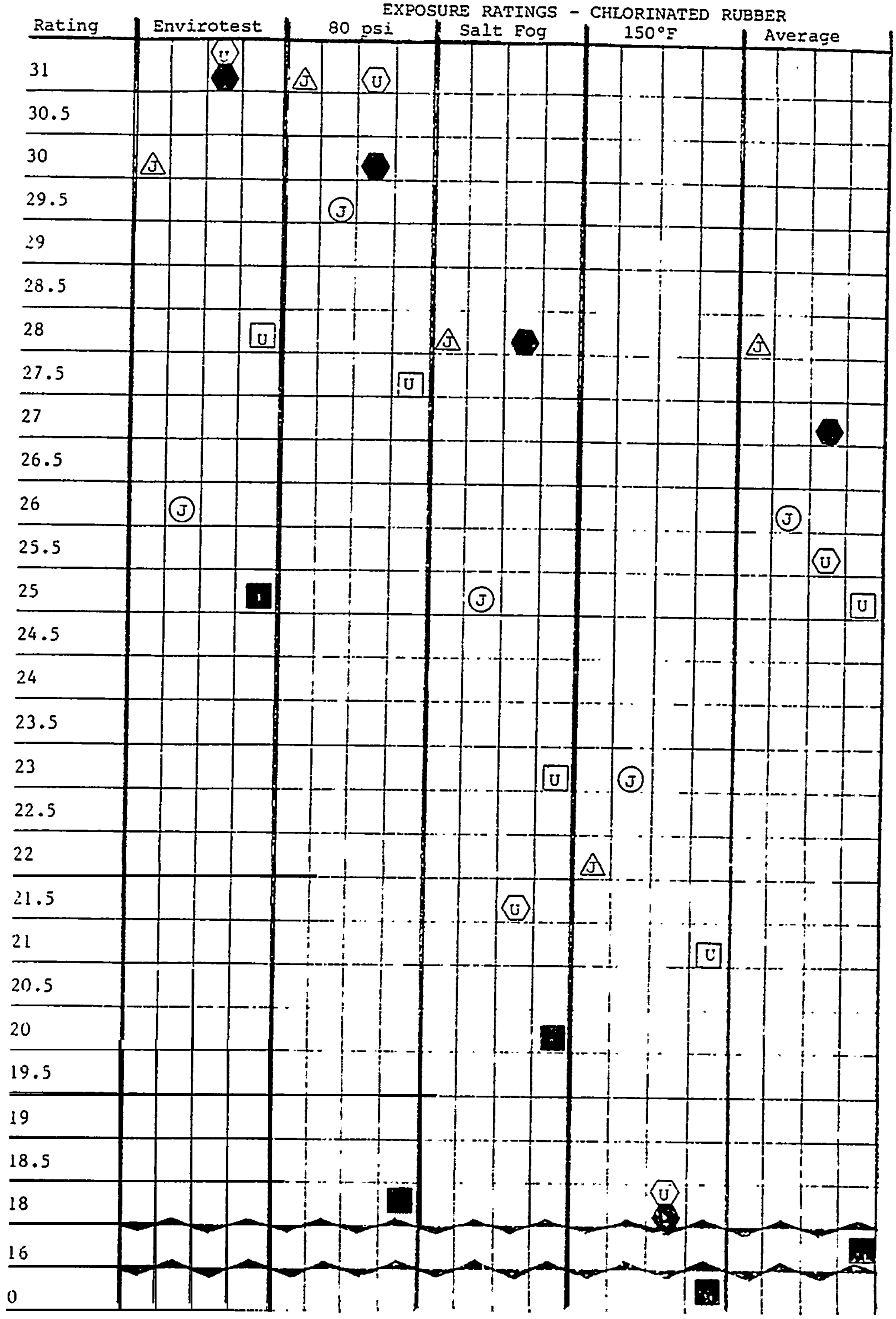
EXPOSURE RATINGS - INORGANIC ZINC



KEY:
J – Japanese Manufacturer A (Japanese Methodology)
J – Japanese Manufacturer B (Japanese Methodology)
U – U.S. Manufacturer A (Japanese Methodology)
– U.S. Manufacturer A (U.S. Methodology)
U – U.S. Manufacturer B (Japanese Methodology)
– U.S. Manufacturer B (U.S. Methodology)

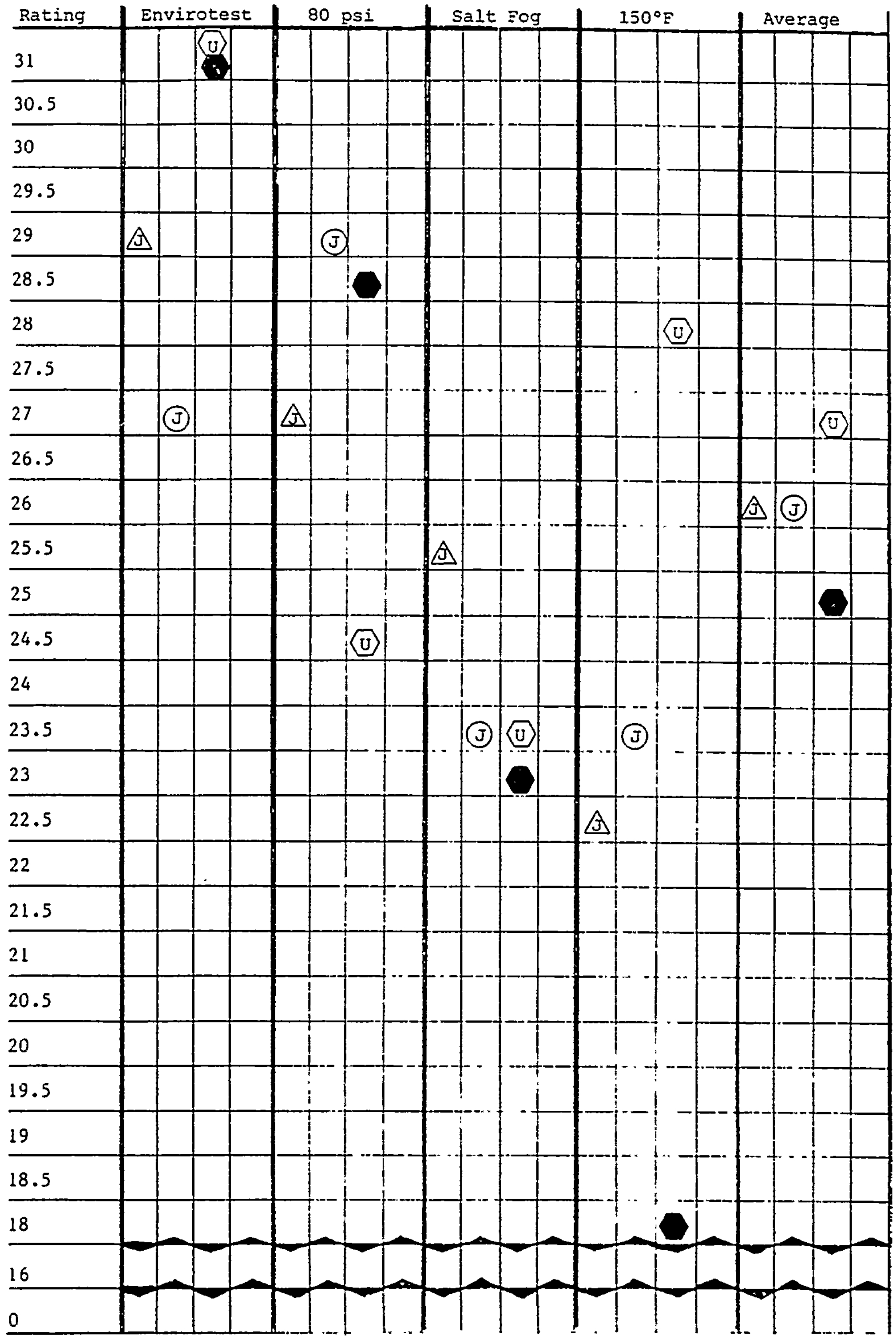
TABLE 14

EXPOSURE RATINGS - CHLORINATED RUBBER



KEY:
- (J in triangle) - Japanese Manufacturer A (Japanese Methodology)
- (J in circle) - Japanese Manufacturer B (Japanese Methodology)
- (U in hexagon) - U.S. Manufacturer A (Japanese Methodology)
- (filled hexagon) - U.S. Manufacturer A (U.S. Methodology)
- (U in square) - U.S. Manufacturer B (Japanese Methodology)
- (filled square) - U.S. Manufacturer B (U.S. Methodology)

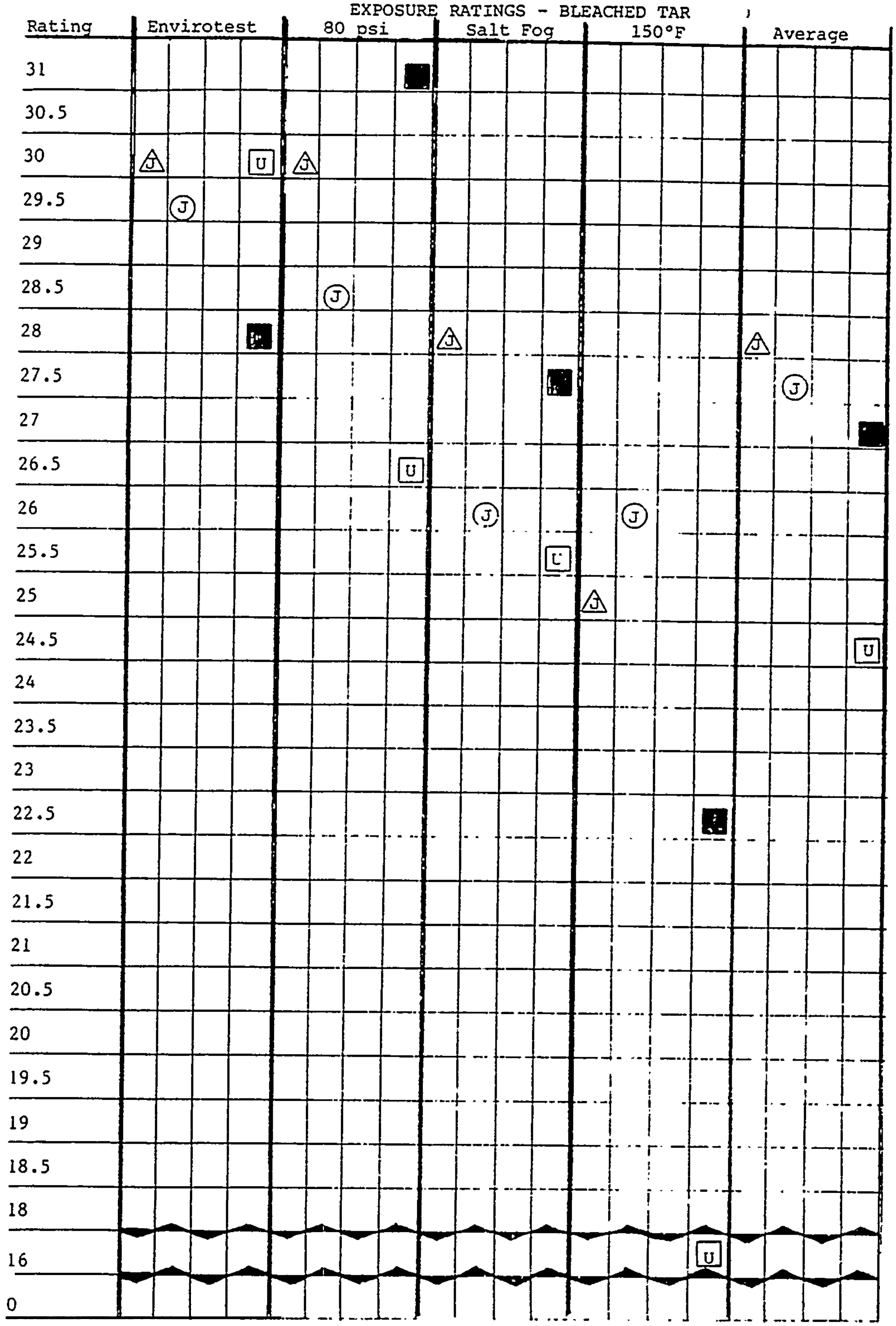
TABLE 15
EXPOSURE RATINGS - VINYL



KEY:
J - Japanese Manufacturer A (Japanese Methodology)
J - Japanese Manufacturer B (Japanese Methodology)
U - U.S. Manufacturer A (Japanese Methodology)
- U.S. Manufacturer A (U.S. Methodology)
U - U.S. Manufacturer B (Japanese Methodology)
- U.S. Manufacturer B (U.S. Methodology)

TABLE 16

EXPOSURE RATINGS - BLEACHED TAR



KEY:

J - Japanese Manufacturer A (Japanese Methodology)

J - Japanese Manufacturer B (Japanese Methodology)

U - U.S. Manufacturer A (Japanese Methodology)

\- U.S. Manufacturer A (U.S. Methodology)

U - U.S. Manufacturer B (Japanese Methodology)

\- U.S. Manufacturer B (U.S. Methodology)

TABLE 17 - FIELD TEST DATA

Table 17 summarizes the test data from 18 months of marine exposure at Ocean City Research Corporations Sea Isle test site.

TABLE 17
FIELD EXPOSURE DATA - 18 MONTHS
RESULTS ACCORDING TO COATING TYPE

Coal Tar Epoxy

System	Panel Face	Weld	Scribe
△ J	Faded and chalking	Rust free	Minor rusting
○ J	Faded and chalking	Isolated corrosion	Corroded
⬡ U	Faded and chalking	Isolated corrosion	Corroded
⬢ U	Faded and chalking	Isolated corrosion	Corroded
□ U	Faded and chalking	Isolated corrosion	Corroded
■ U	Faded and chalking	Rust free	Corroded

Polyamide Epoxy

System	Panel Face	Weld	Scribe
△ J	Faded	Rust free	Minor rusting
○ J	Faded and chalking	Rust free	Corroded
⬡ U	Faded and chalking	Rust free	Corroded
⬢ U	Faded and chalking	Rust free	Corroded
□ U	Faded and chalking	Isolated rusting	Corroded
■ U	Faded and chalking	Rust free	Minor rusting

KEY:

△ J - Japanese Manufacturer A (Japanese Methodology)

○ J - Japanese Manufacturer B (Japanese Methodology)

⬡ U - U.S. Manufacturer A (Japanese Methodology)

⬢ U - U.S. Manufacturer A (U.S. Methodology)

□ U - U.S. Manufacturer B (Japanese Methodology)

■ U - U.S. Manufacturer B (U.S. Methodology)

TABLE 17 (Con't.)
FIELD EXPOSURE DATA - 18 MONTHS
RESULTS ACCORDING TO COATING TYPE

Inorganic Zinc

System	Panel Face	Weld	Scribe
△J	Faded	Rust free	Rust free
○J	Faded	Minor rusting	Rust free
⬡U	Faded	Minor rusting	Rust free
⬡U	Faded	Minor rusting	Rust free
□U	Faded	Minor rusting	Rust free
□U	Faded	Rust free	Rust free

Chlorinated Rubber

System	Panel Face	Weld	Scribe
△J	Faded	Isolated rusting	Minor rusting
○J	Minor rusting	Moderate rusting	Corroded
⬡U	Faded	Moderate rusting	Corroded
⬡U	No deterioration	Isolated rusting	Minor rusting
□U	Faded and chalking	Isolated moderate rusting	Corroded/peeling
□U	Faded and chalking	Rust free	Minor rusting/peeling

KEY:

△J - Japanese Manufacturer A (Japanese Methodology)

○J - Japanese Manufacturer B (Japanese Methodology)

⬡U - U.S. Manufacturer A (Japanese Methodology)

⬡U - U.S. Manufacturer A (U.S. Methodology)

□U - U.S. Manufacturer B (Japanese Methodology)

□U - U.S. Manufacturer B (U.S. Methodology)

TABLE 17 (Con' t.)
FIELD EXPOSURE DATA - 18 MONTHS
RESULTS ACCORDING TO COATING TYPE

Vinyl

System	Panel Face	Weld	Scribe
△J	Faded and chalking	Severely corroded, disbond.	Corroded
ⓙ	Chalking/minor rusting	Moderate rusting	Corroded
⬡U	Faded	Moderate rusting	Corroded
⬢U	No deterioration	Rust free	Rust free
□U	/ A	N/A	N/A
▣U	N/A	N/A	N/A

Bleach Tar

System	Panel Face	Weld	Scribe
△J	Faded and chalking	Rust free	Corroded
ⓙ	Faded and chalking	Isolated rusting	Corroded
⬡U	N/A	N/A	N/A
⬢U	N/A	N/A	N/A
□U	Faded and chalking	Isolated rusting	Corroded
▣U	Faded and chalking	Rust free	Minor rusting

KEY:
- △J - Japanese Manufacturer A (Japanese Methodology)
- ⓙ - Japanese Manufacturer B (Japanese Methodology)
- ⬡U - U.S. Manufacturer A (Japanese Methodology)
- ⬢U - U.S. Manufacturer A (U.S. Methodology)
- □U - U.S. Manufacturer B (Japanese Methodology)
- ▣U - U.S. Manufacturer B (U.S. Methodology)

APPENDIX 1

COATING SYSTEMS

I. PRE-CONSTRUCTION ZINC/COAL TAR EPOXY (JAPANESE METHODOLOGY)

Jap. Mfg. A - Chugoku
- Welbond H (0.6 roil)
- Biscon AC (2 coats @ 5.0 roils each)

Jap. Mfg. B - Nippon
- Zinky 1000 FZ (0.6 roil)
- Epotar M-HB (10.0 roils)

U.S. Mfg. A - International
- Interpolate XUA 115/116 (0.6 roil)
- Intertuf JXA 207/210 (5.0 roils)
- Intertuf JXA 206/210 (5.0 roils)

U.S. Mfg. B - Hempel
- ZS 1577 (0.6 roil)
- Hempel 1513 (2 coats @ 5.0 roils each)

II. PRE-CONSTRUCTION ZINC/SPIO/INORGANIC ZINC/COAL TAR EPOXY (U.S. METHODOLOGY)

U.S. Mfg. A - International
- Interpolate XUA 115/116 (0.6 roil)
- SSPC-SP1O
- Interzinc 22 (QHA 027/028) (2.5-3.0 roils)
- Intertuf JXA 207/210 (5.0 roils)
- Intertuf JXA 206/210 (5.0 roils)

U.S. Mfg. B - Hempel
- ZS 1577 (0.6 roil)
- . SSPC-SP1O
- Galvosil 1562 (3.0 roils)
- Hempadur 1513 (2 coats @ 5.0 roils each)

III. PRE-CONSTRUCTION ZINC/pOLYAMIDE Epoxy (JAPANESE METHODOLOGY)

Jap. Mfg. A - Chugoku

- Welbond H (0.6 roil)
- Epicon Marine HB AL (2 coats @ 4.0 roils each)

Jap. Mfg. - Nippon

- Zinky 1000 FZ (0.6 roil)
- ORGA 1000-4 Primer (4.0 roils)
- ORGA 1000-4 Finish (4.0 roils)

U.S. Mf. A - International

- Interpolate XUA 115/116 (0.6 roil)
- Integrated EXA 471/473 HB Epoxy (5.0 roils)
- Integrated EXA 472/473 HB Epoxy (5.0 roils)

U.S. Mfg. B - Hempel

- ZS 1577 (0.6 roil)
- Hempadur HB 4520 (2 coats @ 4.0 roils each)

IV. PRE-CONSTRUCTION ZINC/SP1O/INORGANIC ZINC/POLYAMIDE EPOXY (U.S. METHODOLOGY)

U.S. Mfg. A - International

- Interplate XUA 115/116 (0.6 roil)
- SSPC-SP1O
- Interzinc 22 (QHA 027/028) (2.5-3.0 roils)
- Intergard EXA 471/473 HB Epoxy (5.0 roils)
- Intergard EXA 472/473 HB Epoxy (5.0 roils)

U.S. Mfg. B - Hempel

- ZS 1577 (0.6 roil)
- SSPC-SP1O
- Galvosil 1562 (3.0 roils)
- Hempadur HB 4520 (2 coats @ 4.0 roils each)

V. PRE-CONSTRUCTION ZINC/INORGANIC ZINC (JAPANESE METHODOLOGY)

Jap Mfg. A - Chugoku

- Welbond H (0.6 roil)
- Galbon S-HB (3.0 roils)

Jap Mfg. B - Nippon

- Zinky 1000 P (0.6 roil)
- Zinky 1000 SPC (4.0 roils)

U.S. Mfg. A - International

- Interplate XUA 115/116 (0.6 roil)
- Interzinc 22 (QHA 027/028) (2.5-3.0 roils)

U.S. Mfg. B - Hempel

- ZS 1577 (0.6 roil)
- Galvosil 1562 (3.0 roils)

VI. PRE-CONSTRUCTION ZINC/SPIO/INORGANIC ZINC (U.S. METHODOLOGY)

U.S. Mfg. A- International

- Interpolate XUA 115/116 (0.6 roil)
- SSPC-SP1O
- Interzinc 22 (QHA 027/028) (2.5-3.0 roils)

U.S. Mfg. B - Hempel

- ZS 1577 (0.6 roil)
- SSPC-SP1O
- Galvosil 1562 (3.0 roils)

VII. PRE-CONSTRUCTION ZINC/CHLORINATED RUBBER (JAPANESE METHODOLOGY)

Jap. Mfg. A - Chugoku

- Welbond H (0.6 roil)
- Revax AC (3 coats @ 1.6 roils each)

Jap. Mfg. B - Nippon

- Zinky 1000 FZ (0.6 roil)
- Rabacoat Primer (2.0 roils)
- Rabacoat Finish (1.6 roils)

U.S. Mfg. A - International

- Interplate XUA 115/116 (0.6 roil)
- Interchlor LP Series HB Primer (3.0 roils)
- Interchlor LF Series Finish (1.5 roils)

U.S. Mfg. B - Hempel

- ZS 1577 (0.6 roil)
- Hempatex Hi-Build 4633 (2 coats @ 3.2 roils each)

VIII. PRE-CONSTRUCTION ZINC/SP1O/INORGANIC ZINC/CHLORINATED RUBBER (U.S. METHODOLOGY)

U.S. Mfg. A- International

- Interpolate XUA 115/116 (0.6 roil)
- SSPC-SP1O
- Interzinc 22 (QHA 027/028) (2.5-3.0 roils)
- Interchlor LP Series HB Primer (3.0 roils)
- Interchlor LF Series Finish (1.5 roils)

U.S. Mfg. B - Hempel

- ZS 1577 (0.6 mil)
- SSPC-SP1O
- Galvosil 1562 (3.0 roils)
- Hempatex Hi-Build 4633 (2 coats @ 3.2 mils each)

IX. PRE-CONSTRUCTION ZINC/VINYL (JAPANESE METHODOLOGY)

Jap. Mfg. A - Chugoku

- Welbond H (0.6 roil)
- Evabond K (0.6 roil)
- Vinyl AC HB (4 coats @ 2.4 roils each)

Jap Mfg. B - Nippon

- Zinky 1000 FZ (0.6 mil)
- Vinilex/2600 AC (2.0 mils)
- Vinilex/2000 (2.0 mils)

U.S. Mfg. A- International

- Interpolate XUA 115/116 (0/6 mils)
- Intervinux VXLOOO Primer (2.0 mils)
- Intervinux VF Series Finish (1.5 mils)

X. PRE-CONSTRUCTION ZINC/SPIO/INORGANIC ZINC/VINYL (U.S. METHODOLOGY)

U.S. Mfg. A - International

- Interplate XUA 115/116 (0.6 mils)
- SSPC-SP1O
- Interzinc 22 (QHA 027/028) (2.5-3.0 mils)
- Intervinux VXLOOO Primer (2.0 mils)
- Intervinux VF Series Finish (1.5 mils)

XI. PRE-construction ZINC/BLEACHED TAR (JAPANESE METH0DOLOGY)

Jap. Mfg. A - Chugoku

- Welbond H (0.6 mils)
- Biscon 1000 NT (2 coats @ 5.0 mils each)

Jap. Mfg. B - Nippon

- Zinky 100 FZ (0.6 mils)
- **Epotar M NB HB (10.0 mils)**

U.S. Mfg. B - Hempel

- ZS 1577 (0.6 mils)
- Hempadur 4563 (2 coats @ 5.0 mils each)

XII. PRE-CONSTRUCTION ZINC/SP1O/INORGANIC ZINC/BLEACHED TAR (U.S. Methodology)

U.S. Mfg. B - Hempel

- ZS 1577 (0.6 mils)
- SSPC-SP1O
- Galvosil 1562 (3.0 mils)
- Hempadur 4563 (2 coats @ 5.0 mils each)